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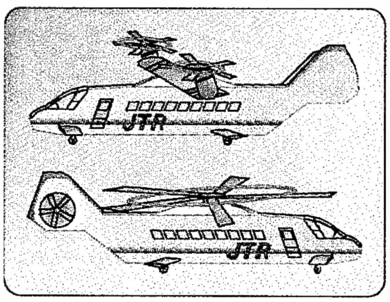

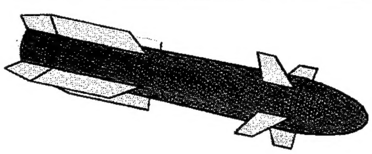

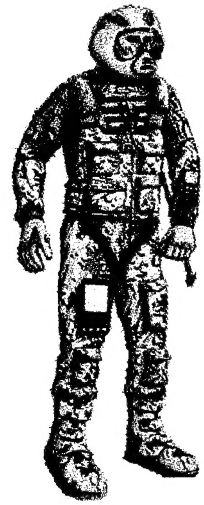

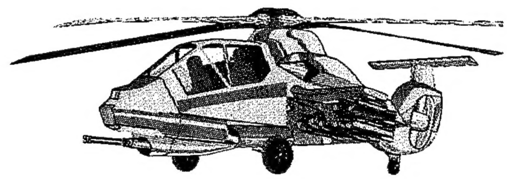

19951211 017

Information Cutoff Date: August 1995

Prepared By:

U.S. Army Aviation and Troop Command
Aviation Research, Development and Engineering Center
ATTN: AMSAT-R-N
St. Louis, MO 63120-1798

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The Aviation RDT&E Plan is provided for planning, programming, administrative and operational purposes within the Department of the Army and for future business planning by non-government entities. It does not authorize nor legally or contractually bind the government for the purchase of any goods or services.

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2 Encl
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TITLE: FY1996 Army Aviation Research, Development, Test, and Evaluation Plan

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DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION AND TROOP COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO 63120-1798

REPLY TO
ATTENTION OF

Directorate for Advanced Systems

NOV 21 1995

SUBJECT: 1996 Army Aviation Research, Development, Test & Evaluation (RDT&E) Plan

1. Enclosed is the Fiscal Year 1996 Army Aviation Research, Development, Test and Evaluation (RDT&E) Plan. The Plan was prepared and published by the Aviation Research, Development and Engineering Center (AVRDEC) in coordination with the Program Executive Office for Aviation, the U.S. Army Aviation Warfighting Center, and with the Major Subordinate Commands of the U.S. Army Materiel Command. Without their valuable input, this plan would not have been possible.

2. The objective of the Army Aviation RDT&E Plan is to provide a concise overview of on-going and planned RDT&E efforts relevant to Army Aviation. It is intended to provide government and industry with insights into the vision and direction of Army Aviation Science and Technology (S&T), advanced research and development, and future concepts. In this way, it is hoped that all sectors can better plan and support their contribution to Army aviation materiel development needs and provide our Army aviators with the best technology available.

3. We also solicit your constructive critique and comments on the Plan so that we can improve it and better meet your needs in developing your plans. Please provide your comments via electronic mail (ASCII text, Word for Windows 2.0 or 6.0, or WordPerfect 5.1) to *millerb@avrdec.army.mil*, by mail to the U.S. Army Aviation and Troop Command, ATTN: AMSAT-R-NBM, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798, by facsimile to DSN 693-1397 or commercial (314) 263-1397, or by telephone to one of the points of contact below.

4. The points of contact are Mr. Bradley R. Miller, AMSAT-R-NBM, DSN 693-1433 or commercial (314) 263-1433, Mrs. Mary Beth Heatherly, AMSAT-R-NST, DSN 693-1470, and Mr. James S. Kirkwood, AMSAT-R-NB, DSN 693-2275.

Encl

David J. Weller
Director of Advanced Systems

1996 Army Aviation RDT&E Plan

ERRATA SHEET

The following correction should be made to the last sentence on page 44 and the first sentence on page 45 (the highlighted portion was erroneously deleted from the final manuscript):

The aircraft systems integration of MEP technologies is essential to a modern system operating at NOE during night and adverse environmental ***conditions, high threat and high speeds. The Aviation RDEC serves the vital role of systems integrator and relies on the coordinated*** development of the MEP technologies of the many supporting government agencies such as MRDEC, ARDEC, CERDEC and ARL.

The legend to the OCR tables in Appendix B (pages B-4 - B-8) is the same as that on page 23.

Please accept our apology for these errors.

MESSAGE FROM THE EXECUTIVE DIRECTOR
AVIATION RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
(AVRDEC)

After a five-year hiatus, the Army Aviation Research, Development, Test and Evaluation (RDT&E) Plan has returned. We have heard from many of our customers and partners in industry who have found it a useful planning tool as a basis for strategic management and business planning and have urged us to revive it. We have shortened it, made it easier to read, brightened it up with some color, and it has been reformatted to reduce redundant information, both within the Plan and with other Army documents that are also widely distributed.

This edition documents the 20-year plan of Army aviation that reflects the current status and projections for technology, technology insertion, and systems development. We have continued to rigorously scrub our programs and make the tough programmatic decisions necessary to meet the critical requirements of our user community within tight budgetary and resource constraints. We remain committed to the concepts of Total Army Quality and continuous process improvement to make the most of the resources available and provide a quality product to our soldiers in the field. Our technology investment strategy is focused on our core technical competencies. Specific technologies for weapons, electronics, and materials are provided by sister RDECs, the DoD, and other sources for integration and insertion into our aircraft systems. Through more effective teaming arrangements and cooperative efforts, we are able to pool and optimize our combined resources. We have adopted the concept of Integrated Product Teams and Integrated Product and Process Development in management and execution of our technology development programs. These processes, together with the adoption of non-government specifications and standards, should improve the efficiencies and effectiveness of our RDT&E programs and help our industry partners to provide more cost effective proposals and products. By streamlining our organizational structure and improving our RDT&E products and services, the AVRDEC is enabled to meet the challenges and implement the intent of the Government Performance and Results Act to improve program effectiveness.

The Comanche and Longbow Apache programs are finally realizing the fruits of our technology programs of the past ten years. The innovative efforts of the government and industry teams for these two programs have resulted in valuable lessons that will be applied to future technology programs. The Rotorcraft Pilot's Associate (RPA) Advanced Technology Demonstration and the three Technology Demonstrations that support the Joint Transport Rotorcraft will be the first beneficiaries.

Finally, we hope that this Plan will enable us to renew and/or strengthen our relationships with our government and non-government partners. Together we can realize our vision and mission to provide the soldier with the world-class aviation technology, systems, and support that they deserve.

Thomas L. House

THOMAS L. HOUSE
Executive Director, Aviation Research,
Development and Engineering Center

TABLE OF CONTENTS

INTRODUCTION

VISION

"To serve as the customers source of excellence for total aviation system support for the entire life cycle of developmental, fielded, and Systems / System Upgrades / Advanced Concepts aircraft"

PURPOSE

The Army Aviation Research, Development, Test, and Evaluation (RDT&E) Plan is a presentation of the 20-year plan of the Army aviation community to develop and integrate new technology, equipment, and subsystems that will respond to the needs of the soldier on the modern battlefield. The Aviation RDT&E Plan is prepared in conjunction with the Army Modernization Plan (AMP), the Army Aviation Modernization Plan (AAMP), the Army Science and Technology Master Plan (ASTMP), and the Research, Development and Acquisition Plan (RDAP) processes. The intent of this Plan is provide Congress, Department of Defense (DoD), Army, and our defense industry partners with a complete picture of RDT&E efforts on-going and planned in support of the aviation modernization strategy. One of the major objectives of the Aviation RDT&E Plan is to provide industry with a tool for planning their long range technology investment goals in synergy with Army requirements. The Plan is structured to provide an overview of Army aviation's user and customer requirements, mission and performance improvements, the flow of technology, and its transition into aviation programs. The Plan is based on funded projects; however a few unfunded projects which have high priority and are critical to the aviation modernization strategy are included.

ORGANIZATION

The Army aviation RDT&E mission is executed by the U.S. Army Aviation and Troop Command (ATCOM), located in St. Louis, Missouri (see Figure 1). Within ATCOM is the Aviation Research, Development, and Engineering Center (AVRDEC) which is recognized and employed by its customers as the source of excellence in total aviation system support for the entire life cycle of developmental, fielded, and next generation/ future systems.

The AVRDEC in St. Louis, MO includes the Headquarters; Directorate for Engineering; Directorate for Advanced Systems; Directorate for Life Cycle Software Engineering; Business Management Office; Materiel Safety Office; and Test and Evaluation Management Office. The Aviation Applied Technology Directorate (AATD) is located at Fort Eustis, VA; and the Aeroflightdynamics Directorate (AFDD) and Advanced Systems Research and Analysis Office

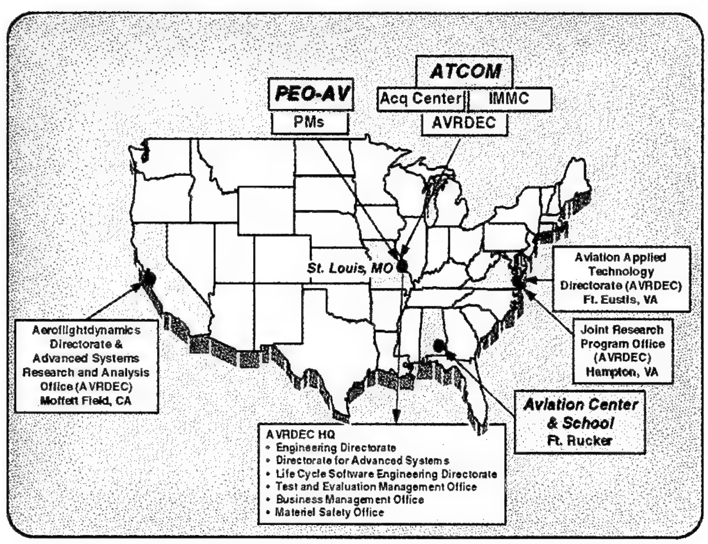


Figure 1. Aviation Organizations (ATCOM, PEO-AV and AVNC).

(ASRAO) are collocated at the National Aeronautics and Space Administration (NASA) Ames Research Center, Moffett Field, CA. The Joint Research Program Office, an element of the Aeroflightdynamics Directorate, is collocated at the NASA Langley Research Center, Hampton, VA. The elements located in St. Louis primarily provide engineering, test and evaluation, and technical staff and matrix support services to the Program Executive Office, Aviation (PEO-AV), ATCOM, and other customers. The AFDD, in close cooperation with NASA, is primarily focused on basic research, concept exploration, and concept development of rotorcraft technologies. The AATD focus is on advanced development, technology demonstrations (TD) and Advanced Technology Demonstrations (ATD) of rotorcraft and support systems technologies.

MISSION AND OBJECTIVES

ATCOM serves as the lead command for the U.S. Army Materiel Command (AMC) to develop, acquire, field, and sustain affordable aviation systems, materiel, and equipment for the total Army worldwide. ATCOM equips Army aviation with a modern, lethal, versatile, deployable, cost-effective, warfighting fleet. Army aircraft systems are managed from cradle to grave, beginning with research and development (R&D), continuing with procurement and production, spare parts availability, new equipment training, safety-of-flight, and following through with maintenance and overhaul to eventual retirement.

The mission of the AVRDEC is to provide life-cycle management, engineering, and technical support to develop and field modern, capable, operationally effective, supportable, survivable and affordable airmobile systems, as well as provide broad technical support to fielded aviation systems. The AVRDEC incorporates aviation's science and technology (S&T), and engineering as they affect aviation systems' design, development, production, and operation. Primary services and products of the AVRDEC are focused on support to the PEO-AV and their program/project/product managers (PMs) and the user represented by the U.S. Army Aviation Center (AVNC) . By virtue of Project Reliance, joint service Memoranda of Agreement (MOA), Cooperative Research and Development Agreements (CRDA), et al., the AVRDEC provides worldwide support throughout the aviation and rotary wing industry, developer and user communities. The AVRDEC plans the future of Army aviation as it researches and develops new systems and advanced technology that resolve current battlefield capability issues and requirements, to counter future threats, and evaluate problems associated with aging aircraft. Using in-house facilities and personnel, contractual programs, joint and collaborative efforts with other government, industry, or academia, R&D is conducted in the following areas, each managed and facilitated by an AVRDEC Team:

- Aeromechanics
- Subsystems
- Mission Equipment Packages
- Propulsion
- Structures
- Reliability and Maintainability (R&M)
- Systems Integration
- Human-Systems Interface (HSI)
- Simulation

The results of these R&D efforts are applied to the following systems:

FIELDED SYSTEMS

- UH-60A/L Black Hawk
- AH-64A Apache
- OH-58D Kiowa Warrior
- CH-47D Chinook
- EH-60A Quick Fix Special Electronic Mission Aircraft
- MH-47E Special Operations Aircraft - Cargo
- MH-60K Special Operations Aircraft - Utility

DEVELOPMENTAL SYSTEMS

- AH-64D Longbow Apache
- RAH-66 Comanche

FUTURE SYSTEMS UPGRADES

- Improved CH-47 (ICH)
- Enhanced Apache
- Improved Black Hawk

with Upgrades/ Mods & Tech Insertion

ADVANCED CONCEPTS

- Joint Transport Rotorcraft (JTR)
- Bird Dog
- Future Attack Aerial Vehicle (FAAV)
- Future Utility Rotorcraft (FUR)
- Airborne MULE
- Multi-Role Mission Adaptable Air Vehicle (MRMAAV)

MANAGEMENT AND OVERSIGHT OF SCIENCE AND TECHNOLOGY

The S&T Program is planned, programmed, and conducted by the Military Departments and the Defense agencies. The departments are responsible for training and equipping the military forces and using the S&T program to provide warfighting and system options for their components. The Service S&T executives and agencies meet under Project Reliance to review S&T programs and eliminate duplication. The Defense S&T Reliance is based on formal agreements among participants in DoD S&T development, which includes budget categories 6.1, 6.2, and 6.3A. The goals and objectives of Defense S&T Reliance are to:

- Enhance the quality of Defense S&T activities
- Ensure the existence of a critical mass of resources that will develop "world class" products.
- Reduce redundant S&T capabilities and eliminate unwarranted duplication.
- Gain productivity and efficiency through collocation and consolidation of in-house S&T work.
- Preserve the vital mission-essential capabilities of the Services throughout the process.

Reliance serves as a formal planning process that streamlines the S&T program. Reliance develops joint planning through four major management oversight bodies: Joint Directors of Laboratories (JDL); Armed Services Biomedical Research, Evaluation and Management Committee (ASBREM); Training and Personnel Systems Science and Technology Evaluation and Management Committee; and Joint Engineers. Each Reliance oversight body maintains its own internal management structure to develop and monitor joint plans. In addition to overseeing the overall Reliance process, the JDL has direct responsibility for joint planning in the broad area of Combat Materiel (inclusive of 26 of the 31 total Reliance Technology Areas). The JDL has 12 Technology Panels, a Management Panel, and Basic Research Panel to provide the forum for joint plan development in Combat Materiel. The JDL twelve technology panels are:

- Advanced Materials
- Air Vehicles
- Command, Control, and Communications
- Computer Sciences
- Conventional Air/Surface Weaponry
- Directed Energy Weapons
- Electronic Devices
- Electronic Warfare
- Environmental Sciences
- Sensors
- Chemical/Biological; Defense
- Space Vehicles

The JDL Technology Panel for Air Vehicles (TPAV) is responsible for development of joint plans involving Air Vehicles technology. The TPAV, chaired by the AVRDEC's Associate Director for Technology, embraces fully five major technology areas and their subordinate sub-areas, making TPAV the largest panel in scope of all JDL technology panels. The five technology areas managed by TPAV are: fixed and rotary wing aircraft, aeropropulsion, integrated avionics, and aero systems.

TRI-SERVICE S&T

Army aviation must leverage other S&T resources to execute an affordable S&T program and provide technology to our customers. Additionally, the aviation S&T program is leveraged to provide direct and in-direct support to Air Force, Navy, Marines, international, and commercial applications. As such, Army aviation is committed to supporting the rotary-wing requirements of our sister services and governmental agencies through Project Reliance, various interservice/interagency Memorandum of Agreement (MOA) and Memorandum of Understanding (MOU), and enhanced interoperability and commonality through the Joint Aeronautical Commanders Group (JACG). A major source of leveraging resources is the Army's cooperative agreement with NASA in the conduct of rotorcraft and propulsion research.

In 1984, the Joint Logistics Commanders (JLC) formed the JACG to identify programs for joint sponsorship or management. The JACG is further charged with facilitating the reconciliation of differences in the services' requirements where a common need exists. The JACG is chartered to "develop and continuously improve joint processes that will facilitate the design, development, and acquisition of aviation systems that are identical or common, and that maximize interoperability." MG John Cusick, Commander, USAATCOM, is the chairman of the JACG through Aug 96. Current JACG efforts include: Aviation Munitions Interoperability; establishing joint procedures for screening aviation-related military specifications and standards that should be replaced with non-Government specifications and standards and those which should be rewritten to performance format; Joint Government Property Operational Working Group to re-engineer government and commercial practices to enhance performance, quality, service, timeliness, and reduce costs of aviation facilities; tri-service symbology R&D for rotorcraft displays and heads-up displays; Advanced Boresighting Equipment; and Joint Air Strike Technology (JAST).

Through MOAs and MOUs, Army aviation is collaborating with the other services on the Joint Integrated Avionics Working Group (JIAWG); Air Warrior; Improved Data Modem; AN/ARC-220 High Frequency (HF) radio for Nap-of-the-Earth (NOE) communications; several Aircraft Survivability Equipment (ASE) programs; Joint Transport Rotorcraft (JTR) requirements; Black Hawk follow-on requirements; various items of Aircraft Ground Support Equipment (AGSE) and Sets, Kits, and Outfits (SKO); Cargo/Slung Load Helicopter Handling Qualities; Generalized Air Mobility Model (GAMM); and the Integrated High Performance Turbine Engine Technology (IHPTET) initiative.

COOPERATIVE PROGRAMS WITH INDUSTRY

We seek to leverage the expertise and innovation of both the traditional defense industries and small business entrepreneurs through the Independent Research and Development (IR&D) and Small Business Innovative Research (SBIR) programs. We have developed international relationships to market, share, and exchange technology through MOUs, Data Exchange Agreements (DEA) and Cooperative Research and Development Agreements (CRDA).

The AVRDEC continues to maintain close ties with its counterparts in the nations four prime helicopter manufacturers (Bell Helicopter Textron, Inc.; Boeing Helicopters; McDonnell Douglas Helicopter Systems; and Sikorsky Aircraft) as well as other members of the defense industry team that support aviation. The AVRDEC is assuring that IR&D efforts are accounted for and are an integral part of Army aviation's S&T investment strategy. Technology Interchange Meetings (TIMs) are conducted with industry to provide a forum for industry to assess, evaluate, and promote their IR&D efforts and for the AVRDEC to provide input to these efforts and to better integrate them with the aviation S&T strategy. The leveraging of IR&D

efforts provides aviation with essential technology at a considerable savings to the government. In FY 94, in the areas of aeromechanics and structures alone, the four prime manufacturers invested nearly $78M leveraged by over $8.6M of AVRDEC funds, a ratio of 9:1.

The SBIR program is providing aviation with considerable leveraging at a small cost, especially in the areas of propulsion and drive train components (in support of IHPTET goals and Joint Turbine Advanced Gas Generator (JTAGG) components), aeromechanics, and high performance computing and simulation in support human factors/human systems integration.

On-going CRDAs with industry include: Boeing Helicopter to develop Aeronautical Design Standards for Cargo Helicopter Handling Qualities Specifications (ADS-33C); McDonnell Douglas Helicopter Systems to design, develop, and integrate improved systems for the AH-64D Longbow Apache (also leverages IR&D); and Sikorsky Aircraft to develop a wide-chord blade concept that incorporates technology improvements in advanced airfoils, anhedral tip design, and low vibration balanced weight configurations. There are 20 CRDAs in place, including all four prime helicopter manufacturers, using the Comprehensive Identification of Frequency Response (CIFER), a mathematical model of vehicle behavior from test data.

INTERNATIONAL COOPERATIVE EFFORTS

The AVRDEC has placed emphasis on international collaborative rotorcraft R&D efforts to optimize the application of limited resources and leverage the investments of the international rotorcraft community. The AVRDEC has led activities establishing and leading to key programs under MOUs with Germany, Israel, and France; The Technical Cooperation Program (TTCP) with the United Kingdom, Canada, Australia and New Zealand; cooperative rotor blade and wind tunnel research with the Netherlands at the Deutschland-Nederlands Windcanal (DNW) facility ; and a variety of other individual agreements. In 1994, the AVRDEC was awarded the American Helicopter Society's Award for International Cooperation.

The Covert Night/Day Operations in Rotorcraft (CONDOR) program is a United States-United Kingdom-NATO CRDA in helmet mounted displays, symbology and advanced flight controls. CONDOR will develop an advanced visionics system coupled with a flight control system to demonstrate enhanced battlefield operations during day, night, and adverse weather conditions. This program provided $19M in NATO Cooperative Test funding to the AVRDEC S&T program and is leveraging significant navigation and symbology technology and funding from the UK. The UK in turn is a customer for the technology and hardware developed for CONDOR.

Other efforts include the Information Exchange Agreements (IEA) and the exchange of technology and articles for testing from France, Israel, Germany, and the UK in the search for a cost effective means of detecting and avoiding wires and other hazardous obstacles in a rotorcraft's flight path. A new start in FY 95 is investigating and integrating the Shorts (UK) Starstreak missile as an alternative for the air-to-air missile requirement.

On the marketing side of business, efforts are continuing to support the AH-64D Longbow Apache, RAH-66 Comanche, CH-47D Chinook, and the UH-60L Black Hawk in the international market place. We have signed an agreement to pursue battlefield interoperability and compatibility through commonality and data exchange between the Eurocopter Tigre and the Boeing/Sikorsky Comanche programs.

COOPERATION WITH OTHER RDECS AND ARMY/DOD/GOVERNMENT ACTIVITIES

Within the Army S&T community, we rely heavily upon other Army RDECs, laboratories, and activities to provide key technologies and components which must be integrated to meet the needs of the Army aviator. We also strive to identify technologies that we are developing that may assist other RDECs, PEOs, and activities meet the needs in other Battlefield Operating Systems (BOS).

Army aviation has relied heavily in the past (and more so in the future) upon other RDECs and overnment laboratory resources and facilities in the development of rotorcraft and rotorcraft-related technologies. The close working agreement with NASA in the sharing of their Ames, Langley, and Lewis Research Centers has maximized the return on investment of scarce research facilities, tools, and manpower. The NASA wind tunnels at these sites have proven to be an invaluable asset in rotorcraft research. Aviation is also working with the Advanced Research Projects Agency (ARPA) as they explore innovative applications of break-through technologies in micro-processing, micro-sensors, and sensor fusion.

The AVRDEC looks to the Communications and Electronics RDEC (CERDEC) for 6.2-6.3 support in communications, night vision and electro-optical devices, and electronic countermeasures. The Armament RDEC (ARDEC) supports aviation through S&T support in ammunition, flares, and gun systems. The major source of aviation weaponization is the Missile RDEC (MRDEC), which provides expertise in missiles, rockets, radar systems, and artificial intelligence and fuzzy logic. The Natick RDEC (NRDEC) supports aviation through development of tactical and maintenance shelters, individual protective clothing and systems, and environmental control systems. The Edgewood RDEC (ERDEC) is aviation's primary source for nuclear, biological, and chemical (NBC) detection and decontamination equipment. The Tank and Automotive RDEC (TARDEC) is a partner in developing crew station and cockpit improvements, turbine engine technology, and navigational and targeting sensors. The Army Research Laboratories (ARL) support aviation through S&T in human factors engineering, meteorological sciences, vulnerability and lethality assessments, research in vehicular propulsion systems, structures and material sciences, modeling and simulation concepts, and other sciences common to mounted systems. *(Note: See Table I for related projects)*

We have also worked with state and local agencies in support of police, firefighting, and disaster relief requirements.

COOPERATIVE SUPPORT FROM ACADEMIA

Additionally, we leverage the resources of academia through the establishment of Centers of Excellence and the Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) program. Centers of Excellence for Rotorcraft have been established at Georgia Institute for Technology (Georgia Tech), the University of Maryland, and the Renssellaer Polytechnic Institute (RPI). Georgia Tech is providing basic research in vibration controls and fuzzy logic flight controls. The University of Maryland is studying advanced concepts in multiple handling qualities criteria through systematic flight control system optimization design. Under the HBCU/MI program, the AVRDEC has provided grants to Hampton University to study "Computational Fluid Dynamic (CFD) Analysis of Advanced Rotortip Design to Reduce Rotor Blade Vortex Interaction (BVI) Noise."

AAMP STRATEGY

The AAMP is co-developed by ATCOM, the Directorate for Combat Developments at the Aviation Center, and the PEO-Aviation. The Aviation Force Development Division, Directorate for Force Development in the Office of the Deputy Chief of Staff for Operations and Plans (ODCSOPS) is the proponent for the AAMP. The Force Development Directorate consolidates the AAMP, along with other modernization plans as annexes to the Army Modernization Plan.

The AAMP is the aviation master planning document and road map for modernization of aviation force structure to provide commanders critical warfighting aviation assets that are technologically superior, capable, survivable, and sustainable. The AAMP documents the user's requirements for aircraft and supporting equipment to respond to the threat environment in the near-, mid-, and far-term battlefield. The AAMP is a useful tool for the materiel developer to determine critical technology and developmental efforts required to provide aviation systems that provide the technological overmatch required.

The objective of the Army aviation modernization strategy (Figure 2) is to reduce the rotary and fixed-wing fleets to four aircraft types each. Materiel modernization focus and priorities are driven by the four tenets shown in : solve the Army's most critical battlefield deficiencies -- reconnaissance/security; maintain our technological edge and world class attack helicopter capability into the 21st Century; enhance command, control, communications, and intelligence (C3I), and joint/combined arms interoperability through battlefield digitization;

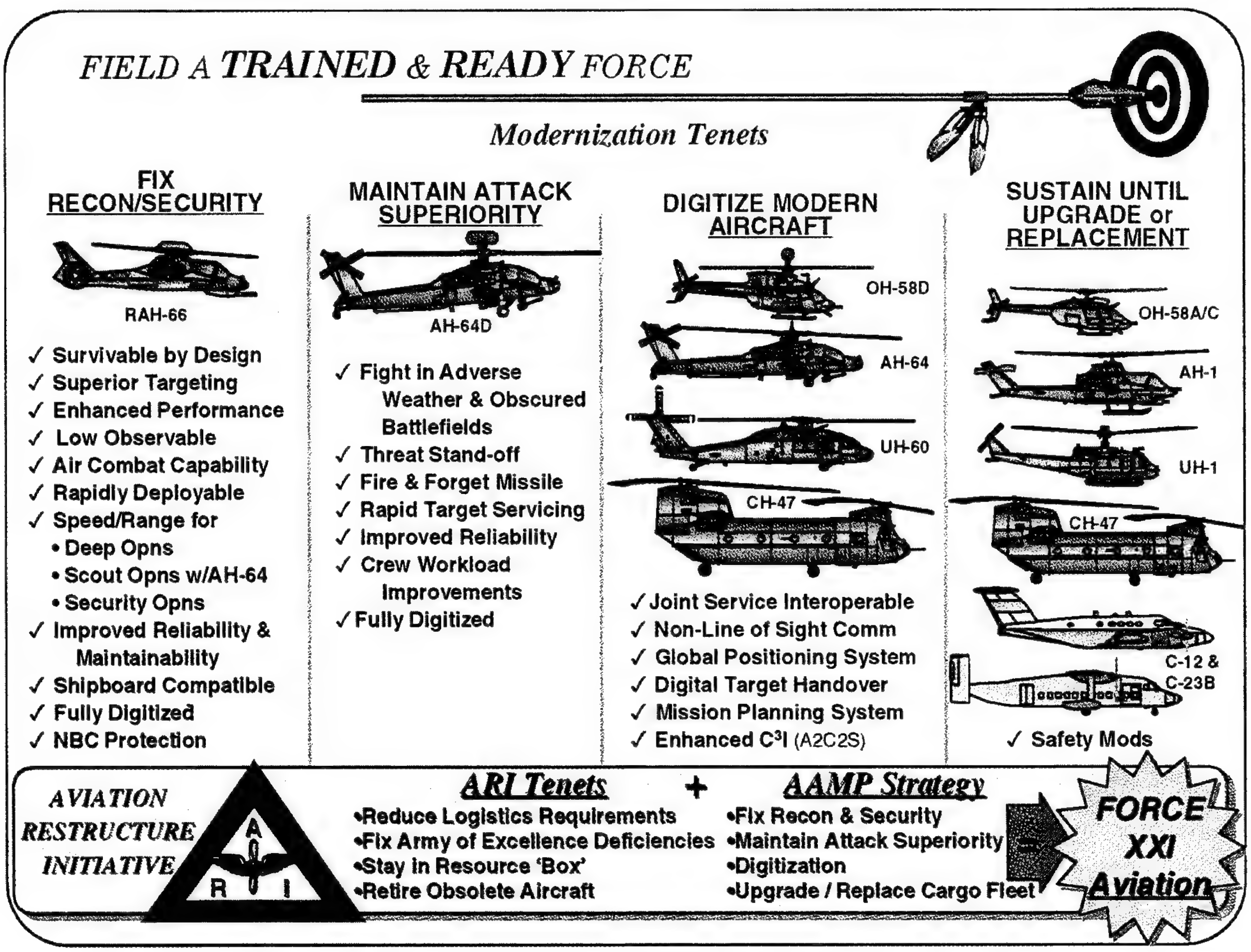


Figure 2. Army Aviation Modernization Strategy.

and sustain our utility, cargo, and fixed-wing capabilities until upgrade or replacement is possible. The goal is to provide our nation the most capable force within resource constraints. The Aviation Restructure Initiative (ARI) is the foundation of this plan. It calls for modernizing aviation units to fix organizational and personnel deficiencies, accelerating the retirement of obsolete aircraft, and equipping the objective force with modernized Comanche and AH-64D Longbow Apache aircraft.

ROTARY-WING FUNDING

Army aviation RDT&E takes into consideration not only the technology available or required, but also the limited resources available to accomplish the efforts. The decline in the overall DoD budget, especially in the RDA accounts, requires that the RDT&E efforts planned are affordable, meet a specific need of our user and customers, and maximize leveraging of technologies and concepts developed by other Army, military, commercial, and foreign sources. Figure 3 and Figure 4 provide a breakdown of the Army aviation RDT&E for the FY 97-01 Program Objective Memorandum. A summary of aviation and aviation-related RDT&E program elements and projects follows at Table I. The table shows the Management Decision Package (MDEP), the RDT&E funding category, and the responsible activity for managing each project.

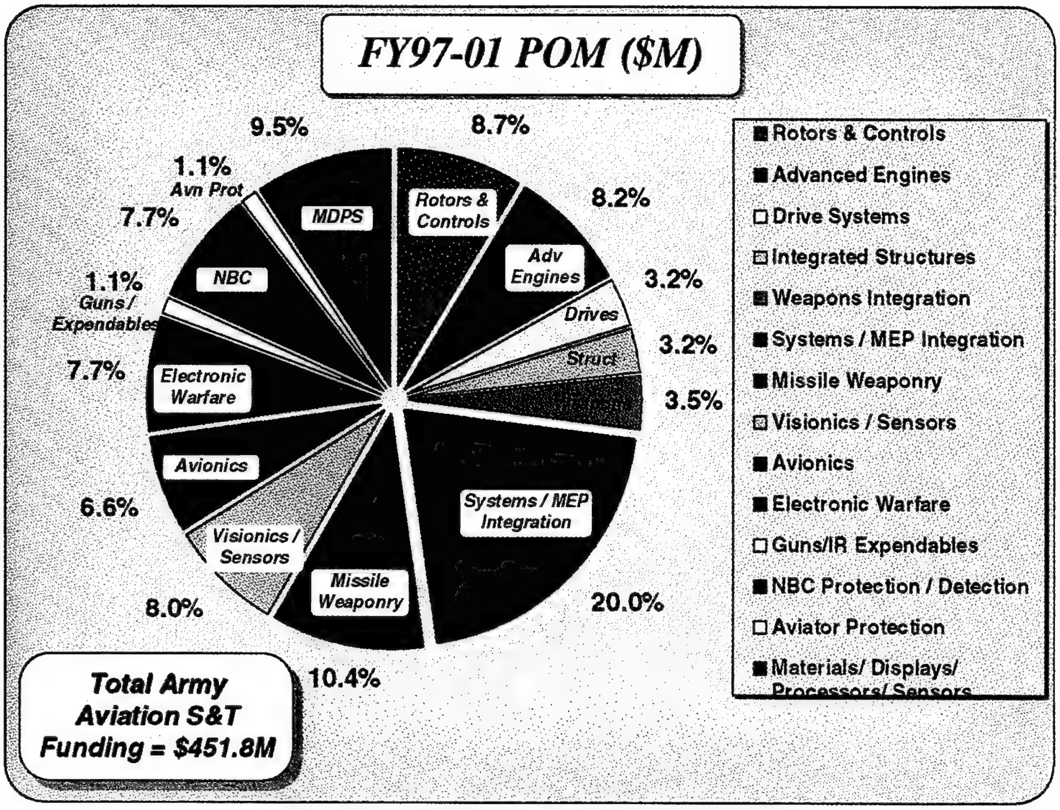


Figure 3. Aviation S&T Funding by Technical Area.

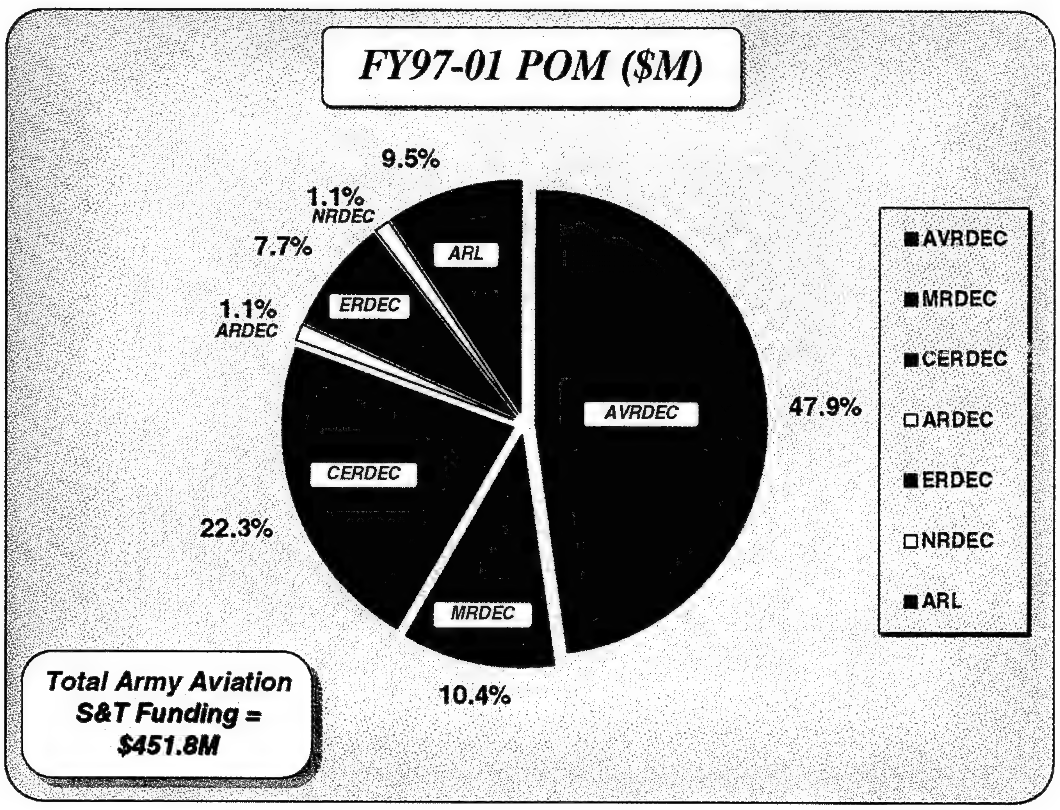


Figure 4. Aviation S&T Funding by Performing Organization.

MDEP	PE	PROJECT	TITLE	Cat	Proponent
RK01	61101	A91A	ILIR	6.1	AMSAT-R-A
RK01	61102	AF20	Advanced Propulsion Research	6.1	AMSRL-VP
RK01	61102	AH45	Air Mobility	6.1	AMSAT-R-A
RK01	61102	AH66	Advanced Structures Research	6.1	AMSRL-VS
RK01	61104	AH59	University Centers of Excellence	6.1	AMXRO
RK01	62211	A47A	Aeronautics & Aircraft Weapons Technology	6.2	AMSAT-R-A / AMSAT-R-T
RK01	62211	A47B	Vehicle Propulsion and Structures	6.2	AMSRL-VP/AMSRL-VS
RK01	62211	AH85	Aircraft Avionics Technology	6.2	AMSEL-RD-EID
RK01	62270	A442	Tactical EW Technology	6.2	AMSEL-RD-NVD
RK01	62303	A214	Missiles Technology	6.2	AMSMI-RD
RK01	62624	AH19	Close Combat Weaponry	6.2	SMCAR
RK01	62624	AH28	Munitions Technology	6.2	SMCAR
RK01	62709	DH95	Night Vision & EO Technology	6.2	AMSEL-RD-NVD
RK01	62782	A779	C2 & Platform Electronics Technology	6.2	AMSEL-RD-C2
RK01	62787	A878	Health Hazards Military Materiel	6.2	USAARL (SGRD)
RK09	63001	D543	Ammo Log (Log Rearm-Avn / Future Avn Log)	6.3	AMSTA-AR-AL
RK13	63003	D313	Research Aircraft Systems	6.3	AMSAT-R-A / AMSAT-R-T
RK13	63003	D435	Aircraft Weapons	6.3	AMSAT-R-T
RK13	63003	D436	R/W Controls & Rotors	6.3	AMSAT-R-T
RK13	63003	D447	Aircraft Demo Engines	6.3	AMSAT-R-T
RK13	63003	DA38	Starstreak	6.3	AMSAT-R-T
RK13	63003	DB39	Advanced Distributed Simulation	6.3	AMSTI-
RK13	63003	DB97	Aircraft Avionics Equipment	6.3	AMSEL-RD-EID
RK14	63313	D263	TACAWS Demos	6.3	AMSMI-RD
RK14	63313	D549	2.75' Anti-Air Technology Demo	6.3	AMSMI-RD
RK15	63270	DK16	Non-Commo ECM Technology Demos	6.3	AMSEL-RD-NVD
RK15	63710	DK70	Night Vision Advanced Technology	6.3	AMSEL-RD-NVD
RK15	63710	DK86	Night Vision, Airborne Systems	6.3	AMSEL-RD-NVD
RK19	63772	D101	Tactical Automation (CAC2/AVTOC)	6.3	AMSEL-RD-C2
RN04	63771	DE20	Manufacturing Science & Technology	6.3	Multiple RDECs / HQ AMC
RD15	63801	DB32	Advanced Maintenance Concepts/Equipment	6.4	AMSAT-R-TL
RD15	63801	DB33	Cargo Handling Equipment	6.4	AMSAT-R-TL
RK16	63004	D232	Advanced Munitions Demos	6.4	SMCAR
RK16	63004	D43A	Advanced Weaponry Technology Demos	6.4	SMCAR
FPEE	63801	DB45	Aviation Life Support Equipment AD	6.4	SFAE-AV-LSE
RJL7	63804	DK39	POL Distribution Equip AD	6.4	AMCPM-PWL
RJL7	63804	DL39	Fuels Handling Equip ED	6.4	AMCPM-PWL
FPEP	64201	DC97	Aircraft Avionics	6.5	SFAE-AV-AEC
FPEF	64220	D538	Kiowa Warrior CSMET	6.5	SFAE-AV-ASH
FPER	64223	D327	Comanche	6.5	SFAE-AV-RAH
FPER	64223	DC72	T-800 Engine ED	6.5	SFAE-AV-RAH
FPED	64270	D665	Aircraft Survivability Equipment	6.5	SFAE-AV-AEC
RD16	64633	D586	Air Traffic Control	6.5	AMCPM-ATC
FPDT	64710	DL69	HTI 2nd Gen FLIR ED	6.5	PEO-C3S / Army Digtzn Ofc
TCAT	64780	D571b	Aviation Combined Arms Tactical Trainer	6.5	AMSTI-ACTS
FPEE	64801	DC45	Aviation Life Support Systems ED	6.5	SFAE-AV-LSE
FPEL	64816	DC13	Hellfire Seeker	6.5	SFAE-MI-HD
FPEL	64816	DC27	Longbow - ED	6.5	SFAE-AV-LB
FPEL	64816	DC31	Longbow-Apache	6.5	SFAE-AV-LB
FPEL	64816	DC87	Longbow - Apache TESS	6.5	SFAE-AV-LB
FPEL	64816	L2DT	LBA Operational Test	6.5	SFAE-AV-LB / AMSTE
FPDB	64999	DP62	GuardRail/Common Sensor	6.5	SFAE-IEW
RL02	65601	D618	Aviation Tech Test Center	6.6	AMSTE-ATTC
RL04	65604	D067	Airworthiness Qualification Support	6.6	AMSAT-R-E/B
RL04	65604	D089	Aircraft Certification	6.6	AMSAT-R-E/B
RL04	65604	D672	Aviation Systems	6.6	ARL - VAL
RL04	65604	DC10	Aviation System Survivability/Lethality	6.6	ARL - VAL
RD17	65606	D092	Aircraft Certification	6.6	AMSAT-R-E/B
RL03	65801	MM43	ATCOM Command/AVRDEC Support	6.6	AMSAT-R-S
FPEH	23744	D179	CH-47D Product Improvement	6.7	AMCPM-CH
FPEA	23744	D423	AH-64 Product Improvements	6.7	SFAE-AV-AAH
FPEH	23744	D430	Improved Cargo Helicopter	6.7	AMCPM-CH
RD17	23752	D106	Aircraft Engine CIP	6.7	AMSAT-R-EP
FPLE	23802	D045	Hellfire Product Improvements	6.7	SFAE-MI-HD
VDRG	35150	D914	Air Recon Low (ARL)	6.7	SFAE-IEW

Table I. Aviation and Aviation-Related RDT&E Projects.

SECTION II. MODERNIZED AVIATION SYSTEMS

The Aviation RDT&E Plan, consistent with the AAMP and the ASTMP, focuses on those R&D efforts which are vital to Army aviation's fulfillment of its future military role. The Aviation S&T Program provides the necessary R&D activity to ensure a balanced technology foundation for the development of future aircraft systems and improvement of existing systems. This section will focus on the more mature R&D efforts that relate to a planned aviation system, a planned upgrade to an existing system or an advanced airvehicle concept.

RECONNAISSANCE / SECURITY

RAH-66 Comanche

The Comanche helicopter program (see Figure 5) was restructured, as directed by the Secretary of Defense on 16 December 1994, to be an industrial/technology base program retaining the two flyable prototypes.

Additionally, the procurement of production aircraft would be deferred beyond FY01. In

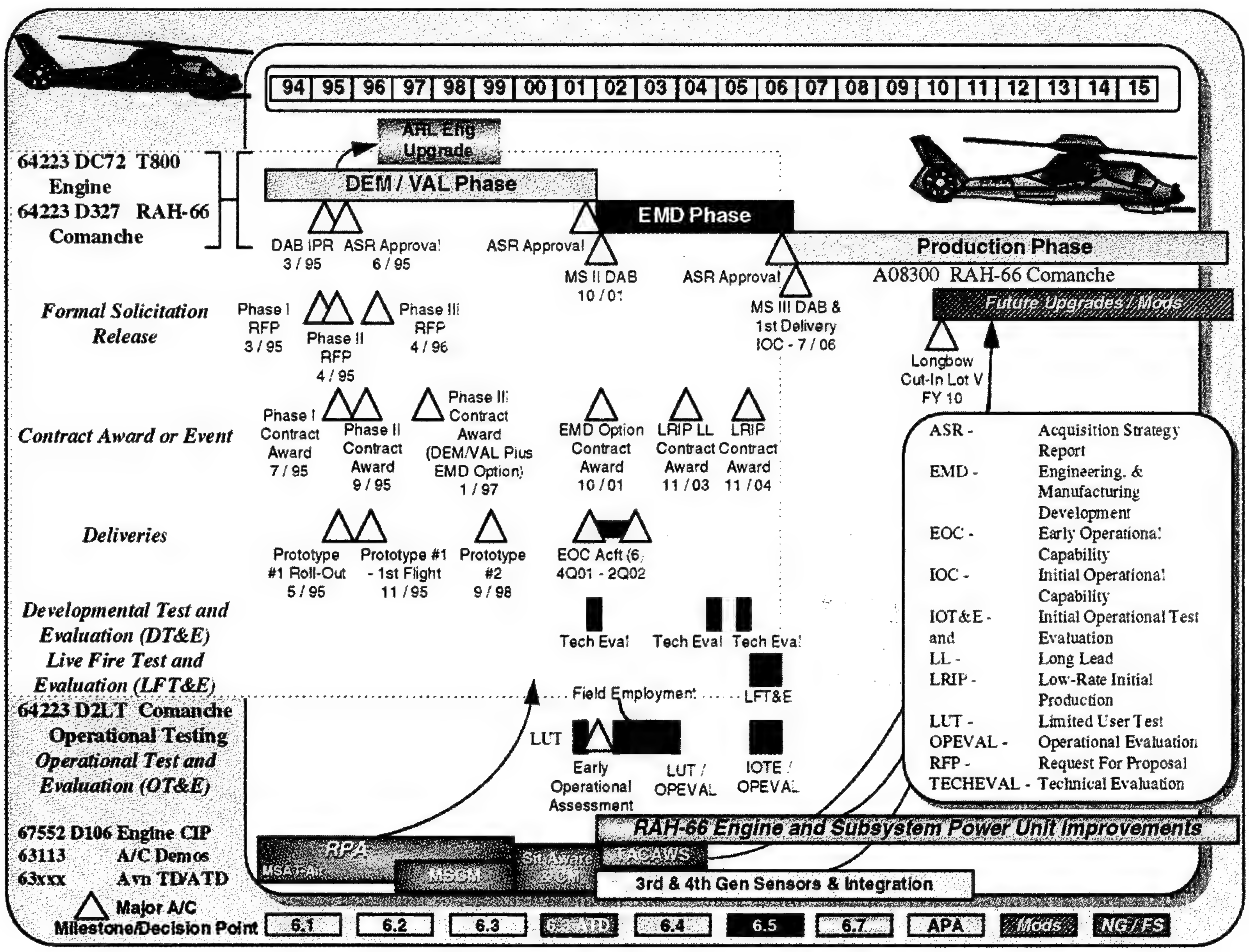


Figure 5. RAH-66 Comanche Program.

compliance with the DoD decision, Army planners aggressively pursued ideas that would enable early user evaluation of Comanche aircraft so that the system could be deployed as soon as practical, with minimal delay to the original approved date for initial operational capability (IOC). As a result, the early operational capability (EOC) concept was developed that would retain the two flight test and mission equipment package (MEP) development prototypes to initially demonstrate the aircraft's airworthiness, flight handling qualities and MEP capabilities. After successfully completing this demonstration, six additional user evaluation aircraft will be built and deployed to the field beginning in FY02 for warfighting evaluation of the Comanche reconnaissance capability. As development flight qualification continues, these six aircraft will be upgraded with armed reconnaissance capability and attack MEP after completion of EOC evaluation. Further warfighting evaluation will be conducted in conjunction with training and initial operational test and evaluation, leading to a full-rate production decision and IOC in FY06. This concept provides a means that will enable a smooth transition into production, and puts Comanche into the hands of the user as soon as possible, thereby assuring the Army that the production Comanche will meet the needs of the modern battlefield.

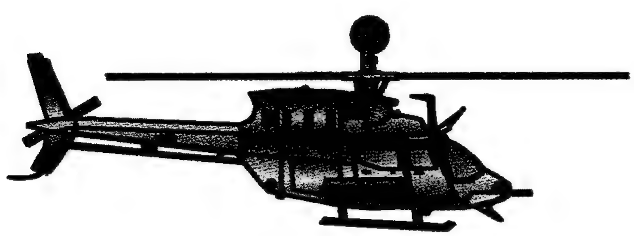
The Longbow fire control radar, which is currently under development for the AH-64 Apache, will be repackaged for the Comanche as a pre-planned product improvement (P3I) item, currently planned to be incorporated on production Lot 5. Future upgrades to the RAH-66 may include technologies from the Rotorcraft Pilot's Associate (RPA) program, and third and fourth generation cockpit and sensor technologies.

Development Quantities	
Fiscal Year	**Prototype Quantity**
FY 96	**1**
FY 97	**1**
	EOC Quantity
FY 01	**2**
FY 02	**4**

Table II. RAH-66 Development Quantities.

A SOUTHCOM Statement of Need to increase the altitude, range and endurance of the RC-7B (DeHavilland DHC-7) in the Airborne Reconnaissance Low (ARL) program has led to an initiative to adapt the T800 to this fixed wing aircraft. Adapting the T800 to the RC-7B would not only enhance the operational capabilities of the current ARL platform, but also provide a springboard evolution into the Aerial Common Sensor (ACS) program.

OH-58D Kiowa Warrior



The OH-58D Kiowa Warrior armed upgrade program will continue through 1997. Current R&D efforts are to develop the OH-58D Crew Station Mission Equipment Trainer (CSMET). Currently, there are no combat mission simulator devices to support institutional and sustainment training of Kiowa Warrior pilots.

The U.S. Army Aviation Center and School, Fort Rucker, AL, is enhancing current OH-58D Cockpit Procedures Trainers with an Image Generator (CPTIG) to meet the Aviation Training Brigade's institutional training requirement. The CSMET will support the training of aircrews in combat operations and employment of the new weapons systems and mission equipment of the OH-58D for fielded units. The CSMET program makes maximum use of existing "off-the-shelf" capabilities, leveraging software from the CPTIG program, and making use of touchscreen cockpit display technology. Out-the-window views, Distributed Interactive Simulation (DIS) compatibility, and compatibility/interoperability with the planned Aviation Combined Arms Tactical Trainer

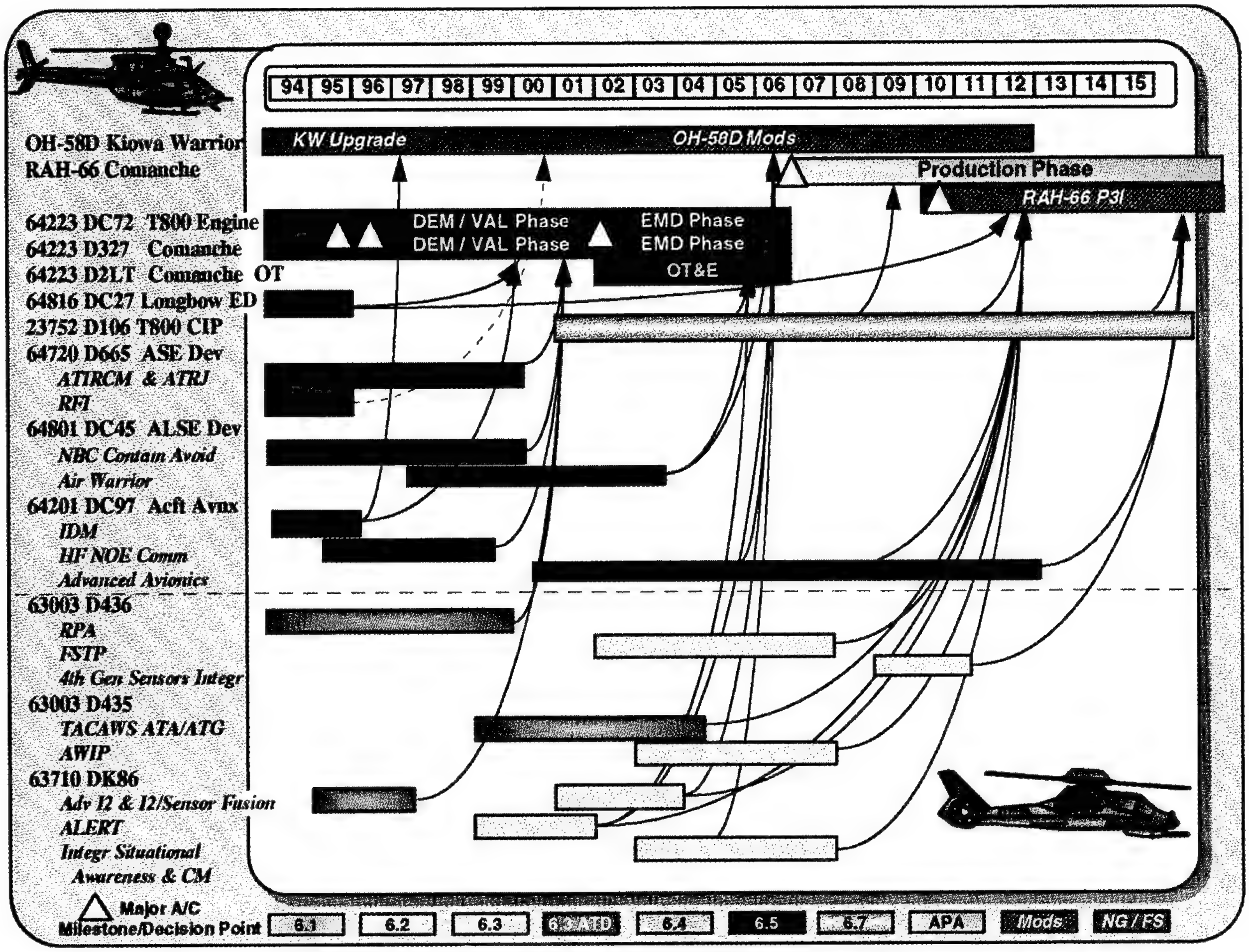


Figure 6. Reconnaissance / Security Fleet Modernization Strategy.

(AVCATT) will be integral to the design considerations.

Planned improvements and technology insertion include the Improved Data Modem (IDM) with the SINCGARS System Improvement Program (SIP) radio, the Embedded GPS Inertial Navigation Unit (INU) (EGI), Aviation Mission Planning Station (AMPS), Havequick II radio, High Frequency (HF) nap-of-the-earth (NOE) radio (AN/ARC-220), video crosslink, and Improved Master Controller Processing Unit (IMCPU). Eight Kiowa Warriors with the above mission equipment will participate in the Task Force XXI brigade and below exercise in Feb 97. Also, the next production lot of T703 engines should include the Full Authority Digital Electronic (fuel) Control (FADEC) for increased performance and safer operations. Technologies from the RPA program and various digitization and sensor programs are future candidates for the OH-58D, depending on mission requirements, to improve situational awareness, survivability, and targeting. The overall reconnaissance and security R&D investment strategy is shown in Figure 6.

ATTACK

AH-64 Apache

The AH-64A Apache is under going a systematic upgrade effort. Current plans are for a block improvement to the AH-64A, which will convert the A model to an AH-64D. Additional enhancements made to 227 Apaches during remanufacture will provide the basis for the Longbow Apache, to include the Longbow millimeter wave fire control radar (FCR) and the uprated T700-GE-701C engines. The upgrade from the baseline AH-64A to the baseline AH-64D Longbow Apache configuration (without the FCR) provides the following enhancements:

- Increased Ordnance Capability (Longbow Hellfire Modular Missile System)
  - *Semi-Active Laser (SAL) Hellfire*
  - *Radar Frequency (RF) Hellfire*
- Increased Automatic Mission Data Loading
- Enhanced Navigation Systems
  - *Deletes HARS*
  - *Incorporates EGI*
- MANPRINT Cockpit
  - *Integrated visual representation of the battlefield - multifunctional displays and graphics*
  - *Secure cockpit lighting*
  - *Improved communications interfaces*
  - *3-axis hover hold*
  - *Improved Data Modem (IDM)*
  - *Digital Communications*
- Vapor-cycle Environmental Control System
- Composite Expanded Forward Avionics Bays
- Increased Electrical Power
- Dual Weapons Processors
- Dual Systems Processors

These will provide greater target location and accuracy, enhance target servicing, improve attack coordination and fires distribution, and minimize engagement exposure. The AH-64D with the FCR mission kit additionally provides:

- Longbow FCR Mast-Mounted Assembly (MMA)
  - *Multi-Mode Radar (air target, ground target, and terrain following modes)*
  - *Radar Frequency Interferometer (RFI)*
- TADS/FCR Integration
  - *Independent, simultaneous operation by either crewmember*
  - *Link/slave operations to FCR or RFI*
- T700-GE-701C Engines
  - *Improved performance over -701 engines*

These enhancements provide the capability for rapid, multiple target acquisition, detection, classification, prioritization, and engagement; extended range acquisition and engagement in adverse weather and battlefield obscurants; and wide area search in minimum time. They enable primary and secondary target designations for each missile; and provide a rapidly-moving target engagement capability. Additionally, the crew's battlefield situational awareness is enhanced with Longbow's tactical situation display of all targets, full 360 degree coverage in the air target mode, digital voice and data connectivity, and its virtual independence of battlefield conditions. The AH-64A Apache and AH-64D Longbow Apache programs include the development of the Apache Crew Trainer (ACT) and the Longbow Apache Crew Trainer (LCT). Both of these trainers provide high fidelity devices for individual and crew qualification and sustainment that are compatible with the AVCATT and interoperable with other combined arms tactical training devices. The ACT prototype has already demonstrated the capability to operate with similar and dissimilar devices using DIS 2.0.3 protocols and digital communications. The initial fielding for the

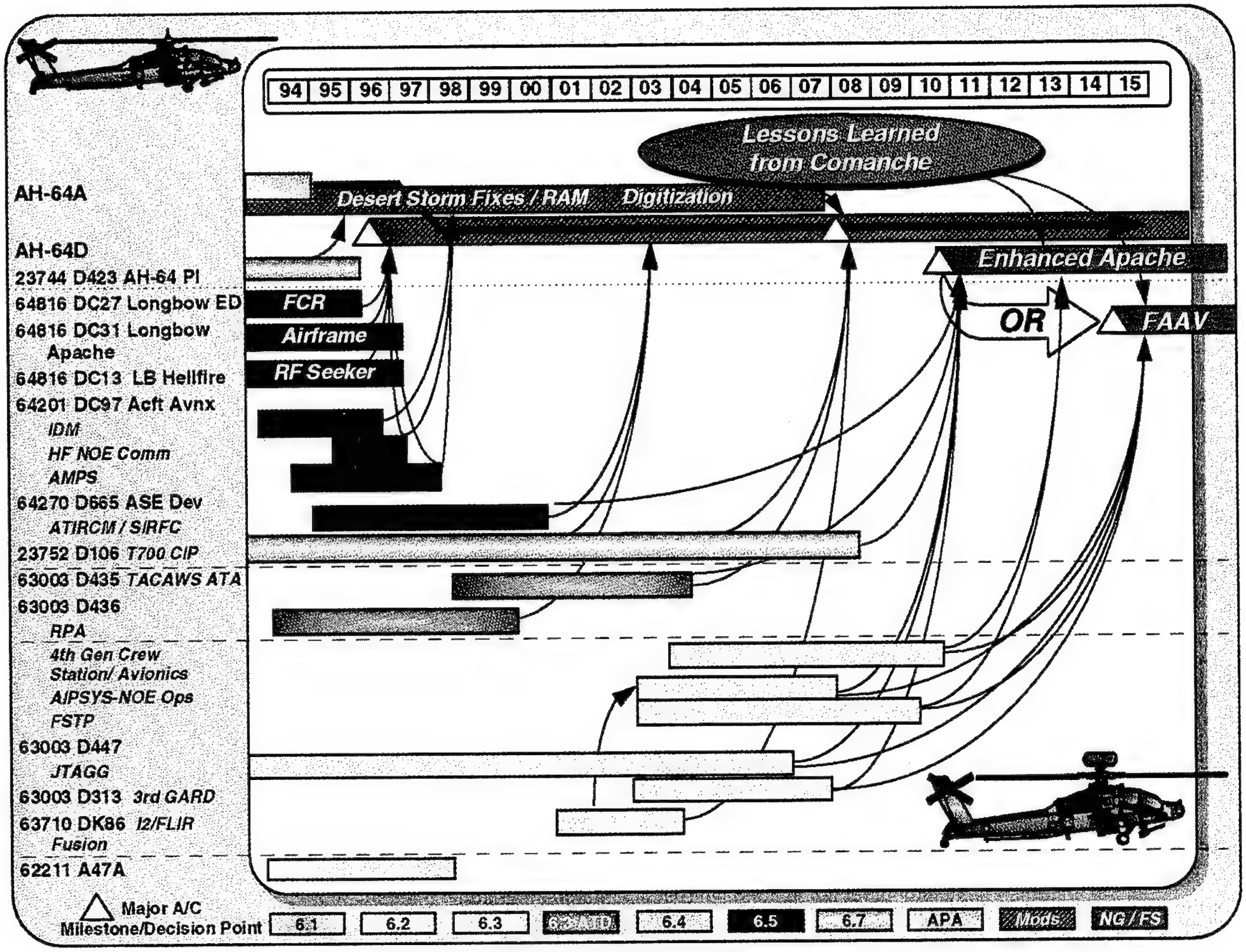


Figure 7. Attack Fleet Modernization Strategy.

ACT is scheduled for 1995. The LCT will be fielded in concert with the AH-64D.

Future upgrades to insert technology into the AH-64D include the Suite of Integrated RF Countermeasures (SIRFC), Advanced Threat IR Countermeasures (ATIRCM), technologies from RPA and follow-on digitization and sensor efforts. The Army Combined Arms Weapon System (TACAWS) may also be applied to the AH-64D. Figure 7 shows the overall strategy technology insertion and modernization of the attack fleet. Technology advances may lead to an Enhanced Apache and/or a Future Attack Air Vehicle (FAAV) in the extreme far-term.

UTILITY

UH-60A/L Black Hawk

A multi-stage modernization program to enhance the entire Black Hawk fleet is planned. All stages are interrelated and build upon the others to achieve the goals of an affordable, supportable, mission capable aircraft for the 21st century. Near-term efforts are focused on the

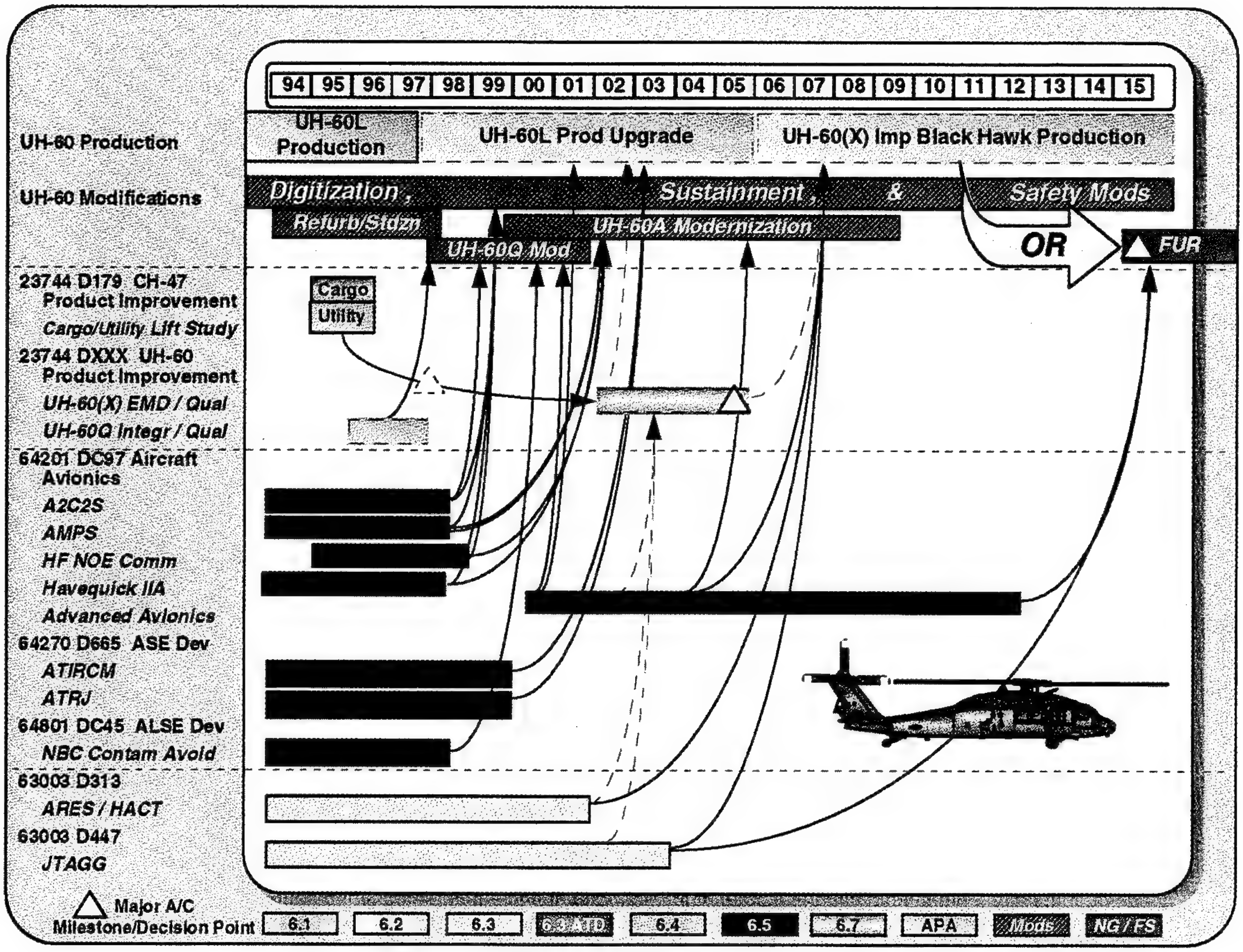
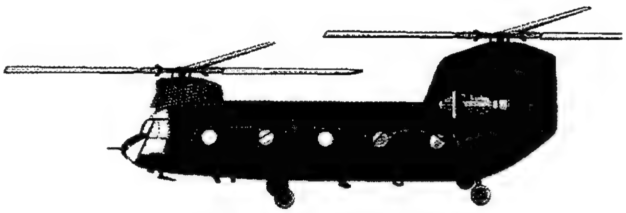


Figure 8. Utility Fleet Modernization Strategy.

standardization of pre-1989 UH-60A models to the 1989 A-model baseline configuration. The modernization concept includes a UH-60L production upgrade of a 1553 bus, improved spindle, new flight control computer, GPS, and the AN/ARC-220 HF NOE Radio. Also planned is the upgrade of selected UH-60s with the Army Airborne Command and Control System (A2C2S). The A2C2S will replace the AN/ARC-15A/B Airborne C2 Consoles.

The UH-60Q Phase II Integration and Qualification effort is a 24-month effort, funded and scheduled to begin Sep 95. The UH-60Q Phase III modification effort for 87 UH-60A aircraft is planned but not yet funded. The UH-60Q will provide an integrated search, rescue, and aeromedical evacuation capability. The Lift Study, scheduled for completion in Jul 95, will provide valuable data for planning the growth of the Black Hawk to the UH-60(X) Improved Black Hawk configuration. This configuration could provide a 9,000 pound lift capability at 4000 feet, 95 degree (F). Ideally, the development and qualification program would begin in FY98 to maximize the synergy between this program and the ICH, especially in regard to the digital architecture of the cockpits. However, affordability issues dictate deferring this program until FY 2002-05 timeframe, with production in FY 2006. Upgrades for consideration include: the UH-60L production upgrades, improved composite rotor blade, growth engine, and the Joint Communication Interface Terminal (JCIT). Future upgrades may also include the SIRFC and ATIRCM. A Future Utility Rotorcraft (FUR) may be required to replace the UH-60 fleet beyond 2015. Figure 8 illustrates the planned upgrade, modernization, and technology insertion of the utility fleet.

CARGO



CH-47D Chinook / Improved Cargo Helicopter

The current CH-47D Chinook is a self-deployable, twin-engine, cargo helicopter capable of operating under adverse weather conditions. Modification Work Orders (MWOs) such as the Engine Air Particle Separators, applied during Desert Storm, have added weight and reduced performance in several areas; e.g. payload, range, and endurance. To return the aircraft to its initial performance capability, along with sustainment upgrades, the Army has developed a CH-47 follow-on concept, Improved Cargo helicopter (ICH), defined by the following objectives: 20 year life extension program, enhanced sustainability, T55-L-714 engines with FADEC replacing current T55-L-712 engines, reduced vibration, and major airframe overhaul. The final ICH design configuration will be determined by a concept formulation and evaluation process. Current RDT&E efforts are planned for 1997-02 as illustrated in Figure 9.

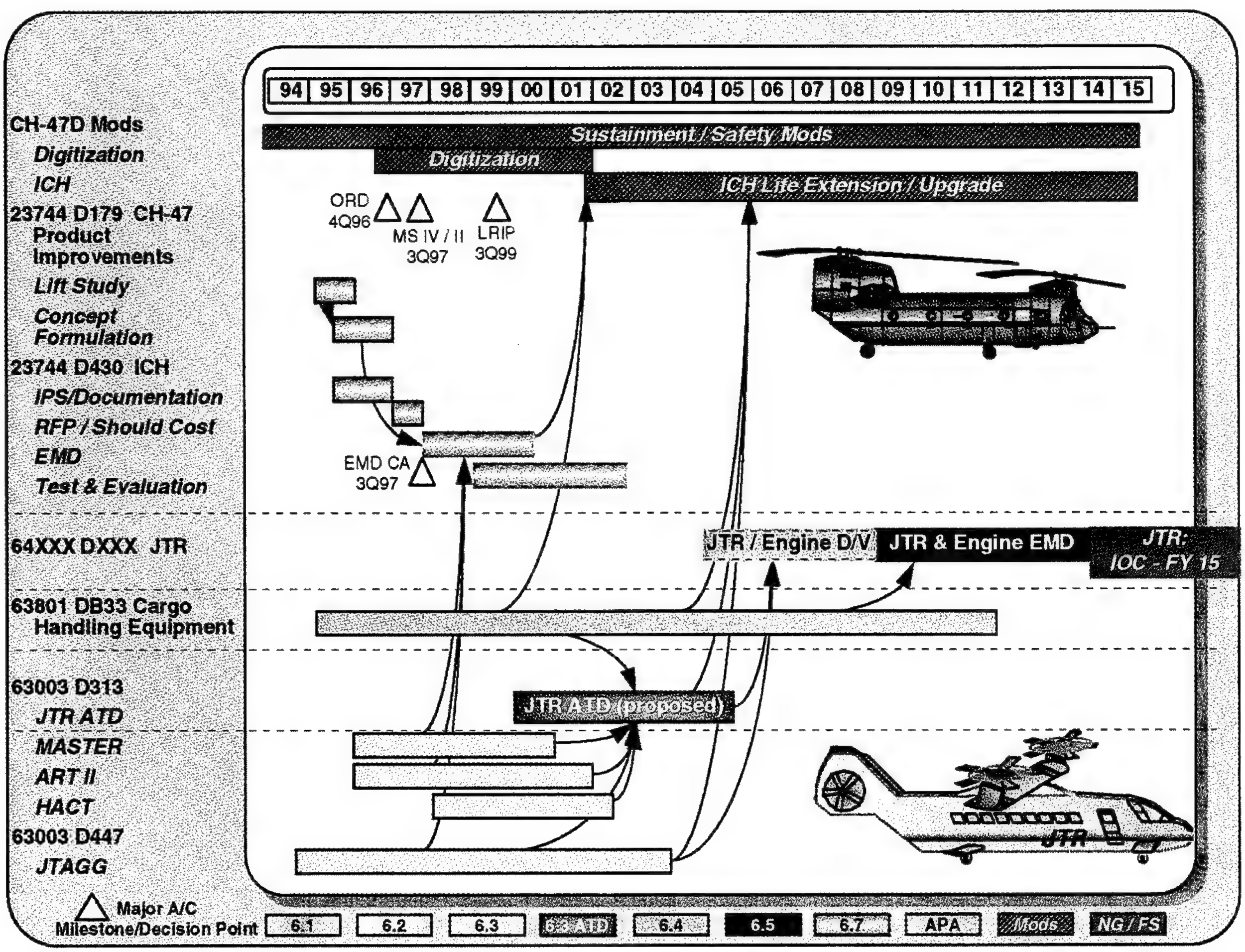
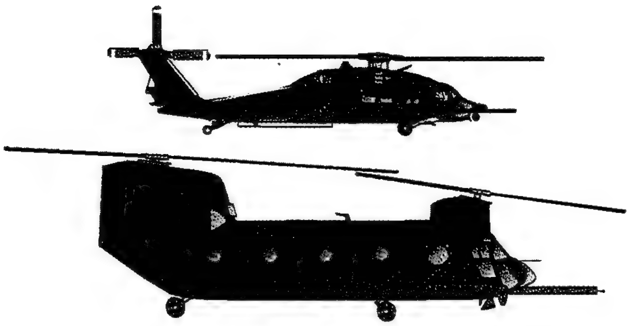


Figure 9. Cargo Fleet Modernization Strategy.

SPECIAL OPERATIONS AVIATION (SOA)



MH-60K Black Hawk SOA

The MH-60K is an original manufactured "K Model." All 22 production aircraft have now been delivered, with the original prototype in the process of receiving production upgrades prior to its fielding to the 160th Special Operations Aviation Regiment (SOAR). The unit's mission capability, however, must be continually enhanced by modifications to current airframes and procurement of new systems which reflect the leading edge of aviation technology. Emphasis for both the near-term and future is placed on increased/improved communications in range and frequencies, navigational accuracy, payload, lethality, and ASE. The standard MH-60K airframe is structurally designed for a life of 20 years. The operational environment flown by the MH-60K, and the rapidly developing technologies around the world require MH-60K airframes to be modernized every 7 years. The modernization concept for the MH-60K fleet is to continue a Service Life Extension Plan (SLEP) for the Black Hawk airframe. Among the changes to be provided are improved wide chord rotor blades and spindles, an upgraded ASE suite, signature reduction, improved Forward Looking Infrared (FLIR), Joint Integration Working Group (JIWG) type avionics, engine growth, and improved navigation capabilities. These modifications will also upgrade some of the basic airframe subsystems.

MH-47E Chinook SOA

The modernization concept for the medium lift rotary wing fleet is to continue a SLEP for the Chinook airframe. Among the changes that may be incorporated are improved tandem four blade rotor systems, upgraded ASE suite to include the complete ATIRCM, SIRFC, signature reduction (IR, RF, and acoustic), engine/powerplant enhancements, small arms ballistic protection system, integrated terrain following/terrain avoidance, improved FLIR, JIWG type avionics and an improved helicopter cargo handling system. Other modifications being considered are: dual winchable cargo hooks, fuselage lengthening, and some of the basic airframe subsystems. All Engineering Change Proposals (ECP) common to the Army CH-47 fleet will be considered for incorporation on the MH-47E.

Figure 10. Bird Dog Helicopter/UAV Team Concept.

ADVANCED CONCEPTS

Bird Dog

The Bird Dog program is a cooperative effort between AATD-ATCOM and AVNC to address critical technologies associated with manned/unmanned aircraft operations. The concept incorporates an unmanned air vehicle (UAV) with manned helicopters to address increased lethality and survivability in such missions as reconnaissance, security, attack, air assault and special operations. Integrating manned/unmanned aviation teams will enhance

warfighting capabilities and increase the team's survivability while reducing crew workload.

The UAV described by the Bird Dog ATD would work with an assigned manned helicopter (MAH) and would be ready to perform its mission without specific direction from the MAH. However, the MAH can modify the mission or selectively downgrade the UAV's autonomy to allow tighter C2 based on mission requirements. The UAV is expected to perform its assigned mission using appropriate flight modes, exposure avoidance, sensor searches, route planning/replanning, and real-time search status reporting. Using artificial intelligence (AI) technology, the UAV will have sufficient decision making capability to perform these tasks, integrate all gathered data, and report the information of interest. There will be no need for continuous data flow unless it is specifically commanded by the MAH or other controller.

When teamed with aircraft conducting a scout/reconnaissance mission, the UAV would be capable of locating enemy weapon systems, identifying targets of interest, and searching terrain areas that are not covered by the MAH sensor suite. In support of an attack mission, the UAV would augment the AH-64/RAH-66 attack team, clearing combat positions, identifying possible firing positions, aiding in locating and identifying priority threat systems, and performing laser designation. Additional missions for the UAV include providing security, communications relay, battle damage assessment (BDA), and battle handovers. The Bird Dog program results in enhanced operational effectiveness of the aviation team and the maneuver commander through improved situation awareness, mission effectiveness, operations tempo, and survivability. Merging two capable platforms, the UAV and MAH will enlarge search areas, reduce vulnerability, and

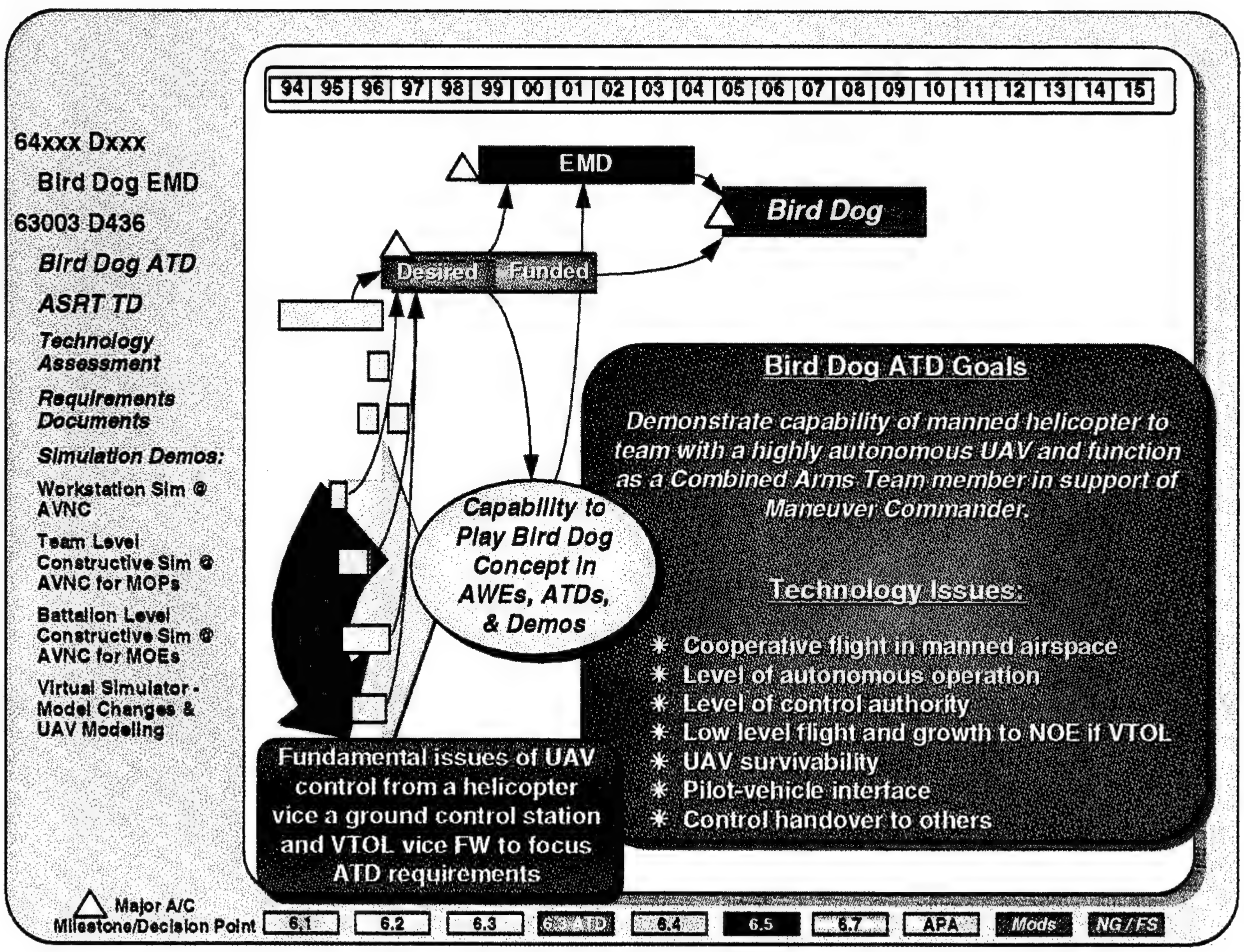


Figure 11. Strategy for Bird Dog Development.

increase attack capability.

FY95-96 are crucial for laying the foundation to define in detail the Bird Dog concept (see Figure 11). Many different descriptions, scenarios, and missions come to mind when the broad concept is discussed. RAND was funded to consider the use of teamed manned and unmanned aircraft for attack, scout/ reconnaissance, air security, and assault missions. The RAND findings support the general Bird Dog concept. There will be a coordinated constructive and virtual simulation effort undertaken to work through the many variables associated with defining the Bird Dog Concept.

An Advanced Technology Demonstration (ATD) Program is scheduled for FY 98-01. Using the results of the Autonomous Scout Rotorcraft testbed (ASRT) and the Bird Dog 6.2 effort, the Bird Dog ATD applies them to existing platforms and sensors. It will be designed to demonstrate specific aspects of the concept in order to evaluate improvements to situational awareness, increased survivability, improved mission effectiveness, and increased Operation Tempo in battlefield scenarios. Pacing technologies to be addressed include: AI, fuzzy logic, man-machine interface, autonomous NOE flight, and high speed digital communications.

Joint Transport Rotorcraft (JTR)

In support of future Army aviation systems requirements and in an environment of declining resources, the dual-use science and technology programs for both military and civilian application are being pursued. Under this trust, the Joint Transport Rotorcraft (JTR, formerly National Transport Rotorcraft or NTR) is envisioned as an air vehicle with the potential to address dual-use technologies as well as utilization by all four services (Figure 12). Key areas that have the greatest dual-use potential for technology application to cargo/commuter rotorcraft investigated under this initiative are: lightweight, reliable transmission; advanced flight controls; highly efficient rotor, smart structures, to include materials and manufacturing; and simulation and virtual prototyping.

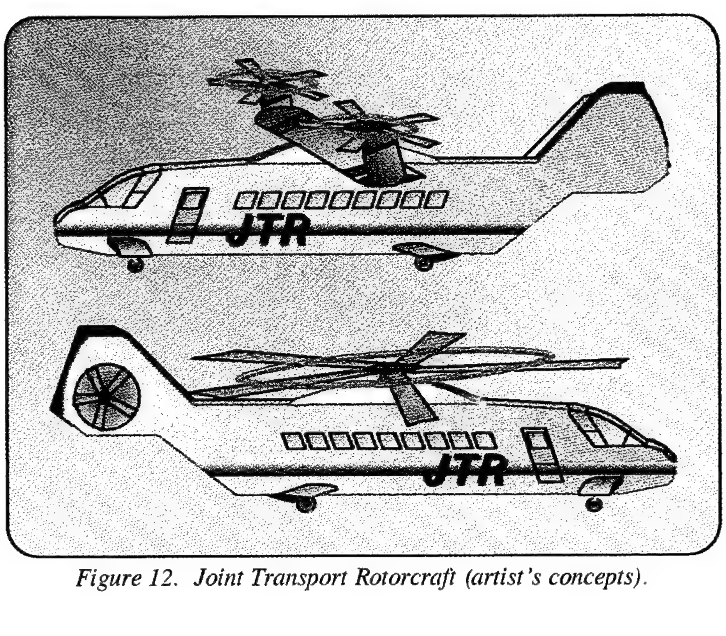


Figure 12. Joint Transport Rotorcraft (artist's concepts).

A preliminary investigation of dual-use applications, a study contract with the RAND Corporation, has been completed. A multi-service team has met to discuss a common joint program, a macro level program outline has been drafted. In house efforts investigating joint service requirements have begun. A conceptual air vehicle configuration has not yet been selected. In FY 96, concept analysis, cost estimation and military worth evaluation will begin. Technology demonstration programs, Advanced Rotorcraft Transmission (ART) II, Manufacturing and Structures Technology for Efficient Rotorcraft (MASTER), and Helicopter Active Control Technology (HACT), support a JTR Advanced Technology Demonstration planned for initiation in FY 2000 (see Section III). It is expected that the ATD will be a JTR component demonstration. Virtual simulation and JTR design follows the ATD, with fabrication, airworthiness testing and evaluation scheduled for completion in FY 2014. The first production aircraft would be delivered in FY 2015. It is envisioned that the JTR air vehicle will

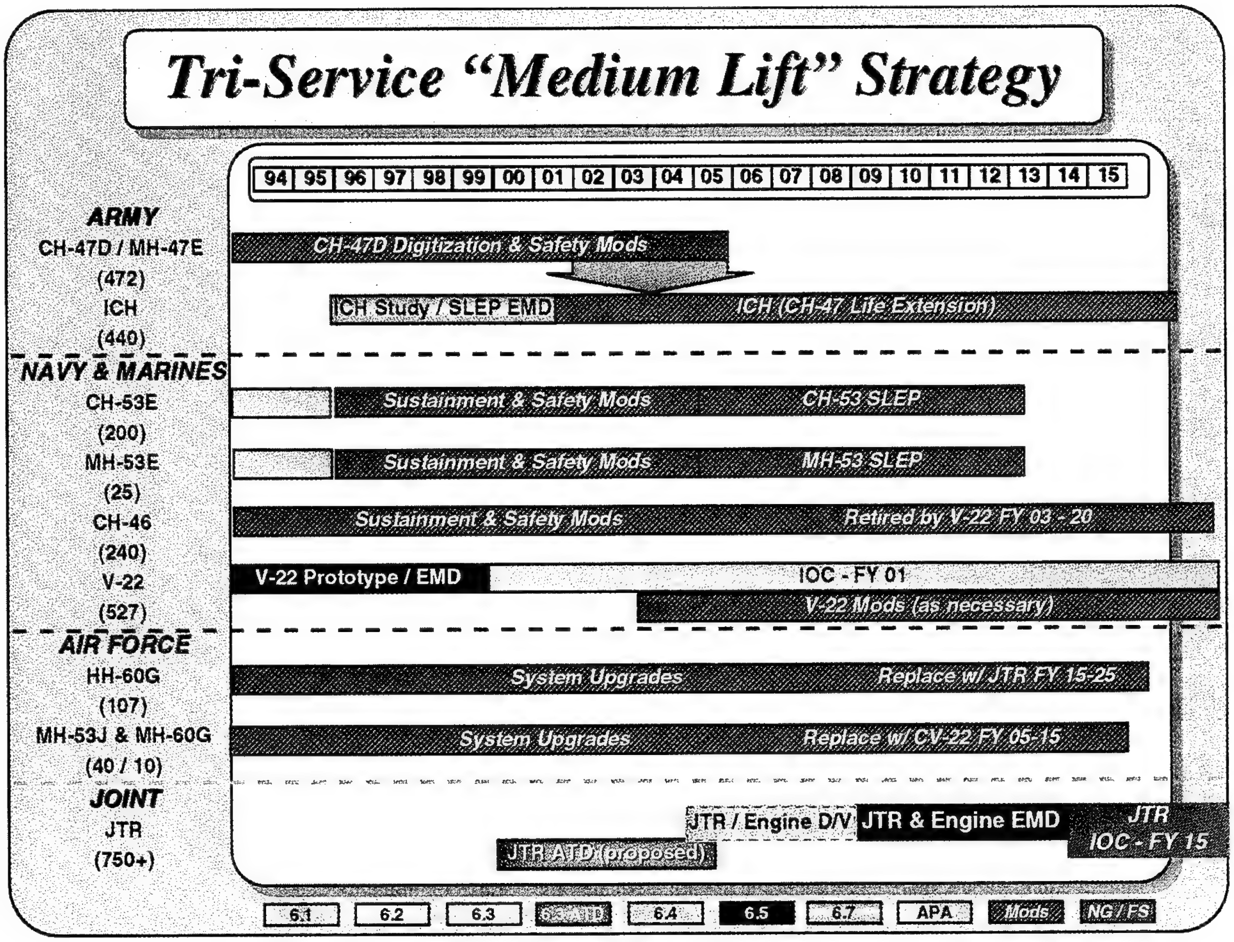


Figure 13. JTR: A Tri-Service Medium Lift Strategy.

replace the Army's improved CH-47D (ICH), the Navy/Marine CH-53E and MH-53E, and the Air Force HH-60G. Early estimates indicate that more than 750 JTR air vehicles are required to fulfill DOD service requirements (see Figure 13).

Multi-Role Mission Adaptable Air Vehicle (MRMAAV)

Army aircraft are increasingly called upon to perform world-wide missions of considerably different roles. Levels of intensity cover a wider spectrum, including Operations Other Than War (OOTW). Having the right aircraft, in the right configuration, in the right place, has always been a challenge. Sometimes the emphasis is on reconnaissance, other times lethality against armor, occasionally attack of "soft" targets, and still other times, world-wide self-deployment into a highly dynamic and fluid environment is demanded. The variety of roles demanded of our ever shrinking force structure and fleet is actually increasing in today's uncertain world. Given a limited number of rotorcraft in any given mission area, it would be highly desirable to tailor each aircraft to an optimum configuration to conduct "operations-of-the-day." MRMAAV seeks to demonstrate the multi-role mission capabilities of a single rotorcraft when equipped with different, interchangeable mission equipment packages. Varied ASE, avionics, communication/navigation, target acquisition, and pilotage suits could be fitted in combination with simulated weapons (missiles, cannon, rockets, DE) to explore this concept. A flying demonstrator, to allow field evaluation of this concept by aviators, is also planned.

Airborne Modular Unmanned Logistics Express (MULE)

The Airborne MULE (Figure 14) is a highly automated air vehicle that will provide logistical movement of modular loads. The unmanned air vehicle will be capable of load movement up to 10,000 lbs and will require little or no manned interaction. Airborne MULE will have cargo payload identification and location intelligence and automated pickup and delivery capability. Virtual prototyping and design for the Airborne MULE is currently planned to begin in FY 2007, with flight test and virtual verification concluding in FY 2010.

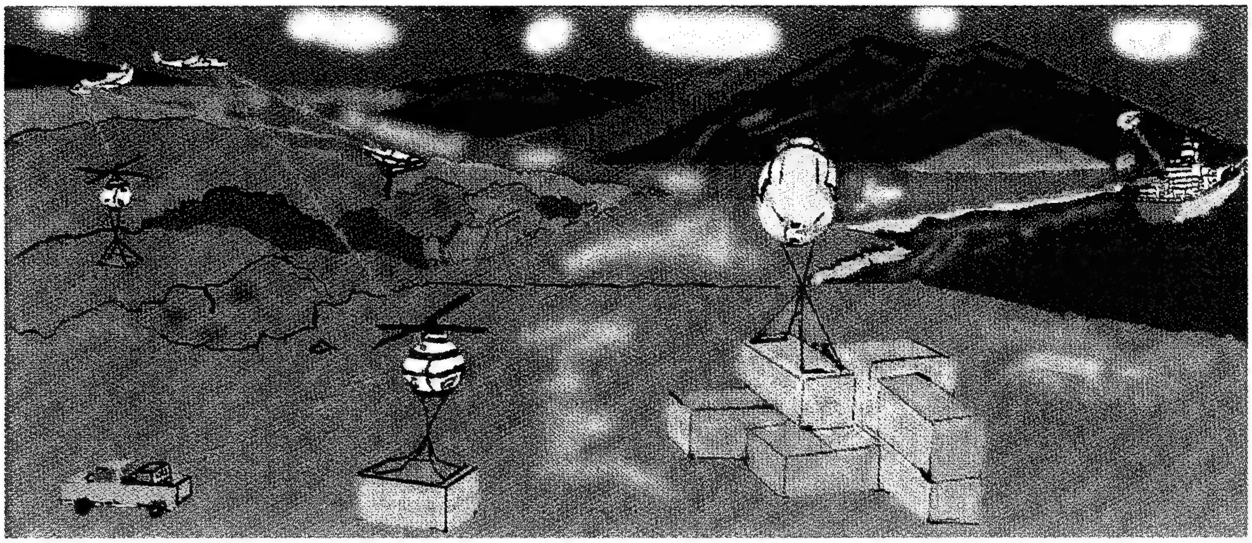


Figure 14. Artist's Concepts for Airborne MULE.

OPERATIONAL CAPABILITY REQUIREMENTS (OCRS)

Operational Capability Requirements are statements of required capabilities for the Army to fulfill the vision articulated within TRADOC Pam 525-5 and the Battle Lab concepts. The set of OCRs is published under TRADOC Pamplet 525-66 and updated at least once every two years. The OCRs are intended to provide a war fighting focus for the Army's S&T investment.

The following table (Table III) contain the Battle Lab crosswalk to respective aircraft systems, system upgrades, and advanced concepts.

The table summarizes the linkages between these programs and the battlefield dynamics, but does not address specific OCRs as the OCR reference numbers may change over the life of this Plan. Appendix B, summarizes each Battle Lab/Battlefield Dynamic. A crosswalk to Aviation S&T programs is also included.

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: PEO-Aviation and ATCOM - AVRDEC

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability: BC	CSS	D&SA	DBS	MTD	EELS
6.2	62211	A47A	47A05	DA2025	**Advanced Concepts.** (Bird Dog, JTR, MRMAAV, FAAV, Airborne MULE, FUR, etc.)		●	○		○	
6.3	63003	D313	31304	NTR3000	**Joint Transport Rotorcraft (JTR).** Increased survivability, payload, and range. Increased mobility.		●	●	●	●	●
6.3	63003	D436	43602	ATD3102	**Bird Dog.** Increased lethality and survivability. Improved situational awareness and C3I. Real-time intelligence, reconnaissance, targeting, and BDA.	●	○	●	●	●	●
6.3	63003	D313	TBD	TBD	**Multirole Mission Adaptable Air Vehicle (MRMAAV)**		○	○	○	○	○
6.3	63003	D313	TBD	TBD	**Airborne MULE.** Increase survivability, payload, and range.		●				
6.2 6.3	62211 63003	A47A D313	47A09 TBD	NRTC200 NRTC300	**National Rotorcraft Technology Center (NRTC).** Increased survivability and lethality, reduce O&S costs.		●	○	○	○	○
6.4 / 6.5 6.4 / 6.5	64223 64223	D327 DC72	01 01		**RAH-66 Comanche.** Increased lethality and survivability. **T800 Engine.** Increased maintainability and durability. Reduced logistical burden. Increased range and payload.	● 	 ○	● ○	● 	● ●	● ○
6.5 6.5	64220 64220	D518 D538	01 01		**OH-58D Kiowa Warrior.** Increased lethality and survivability. **OH-58D CSMET.** Increased lethality and survivability.	●	○	●	○	●	●
6.5 6.5	64816 64816	DC27 DC31	01 01		**AH-64D Longbow Apache.** Increased lethality and	○		●	●	●	●
6.7	23744	D423	01		**Enhanced AH-64.** Increased lethality.	○		●	●	●	●
6.7 6.7	23744 23744	D179 D430	01 01		**CH-47D (IMP) / Improved Cargo Helicopter (ICH).** Increased survivability and payload.		●	●	●	●	●
6.7	23744	DXXX			**Improved UH-60.** Increaesd survivability and payload.		●		●	●	●
6.7					**MH-60K.** Increased lethality				●		●
6.7					**MH-47E.** Increased lethality				●		●

Table I. OCR Crosswalk to Aviation Systems and System Upgrades.

● Provides Significant Capability
○ Provides Some Capability

SECTION III . RESEARCH AND DEVELOPMENT

This section describes the Army aviation R&D program which is presented in two parts. The first part describes the aviation S&T program (RDT&E funded 6.1, 6.2, and 6.3). The second part describes the aviation systems and subsystems development program (RDT&E 6.4, 6.5, and 6.7). Both parts include the funded and high priority unfunded efforts, to include contributions from other Army RDECs and government agencies which are vital to the successful accomplishment of the aviation S&T and development program.

AVIATION SCIENCE AND TECHNOLOGY (S&T) PROGRAM OVERVIEW

Planning Process

The aviation S&T program is an integral part of the DoD S&T program through the hierarchy of plans shown in Figure 15. The Director of Defense Research and Engineering (DDR&E) documents its S&T vision, objectives and investment strategy in 19 technology areas, each of which has its own Technology Area Plan (TAP) The 16 DoD TAPs relevant to Army aviation are listed below. The TAPs of greatest relevance to Army aviation are "Air Vehicles", "Aerospace Propulsion and Power", and "Human Systems Interface." The AVRDEC has supported the development of these TAPs from the beginning. As the Joint Director of Laboratories S&T Reliance lead agency for rotorcraft, the AVRDEC prepares the Rotory Wing Vehicle (RWV) section of the Air Vehicles TAP. The aviation community has interest in and coordinates all other TAPs.

Aviation Related DoD TAPs

- Aerospace Propulsion and Power
- Air Vehicles
- Chemical and Biological Defense
- Command, Control, and Communications
- Computing and Software
- Conventional Weapons
- Electronics
- Electronic Warfare
- Directed Energy Weapons
- Environmental Quality
- Human Systems Interface
- Manpower, Personnel and Training
- Materials, Processes and Structures
- Sensors
- Manufacturing Science and Technology
- Modeling and Simulation

Under the DDR&E TAP guidance and oversight, the Army formulates its investment strategy and presents it in the ASTMP. Primary areas of focus in the ASTMP include Science and Technology Objectives (STO), Advanced

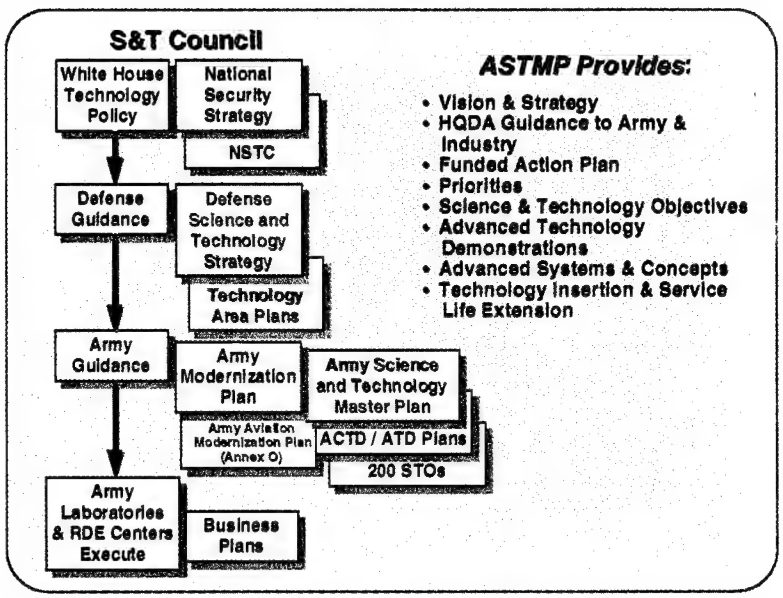


Figure 15. Hierarchy of Plans.

Technology Demonstrations (ATD), and Systems/System Upgrades/Advanced Concepts (S/SU/AC). The primary customer focus of the strategy are the OCRs of the TRADOC Battle Labs. The OCRs are derived within the framework of historical lessons learned from operational experiences as well as the opportunities provided from technology exploitation. The Battle Labs are shown in Figure 16. While TRADOC's U.S. Army Aviation Center at Ft. Rucker, Alabama leads no Battle Lab, it coordinates with all Battle Labs to insure aviation capabilities and S&T programs are integrated in Battle Lab strategy.

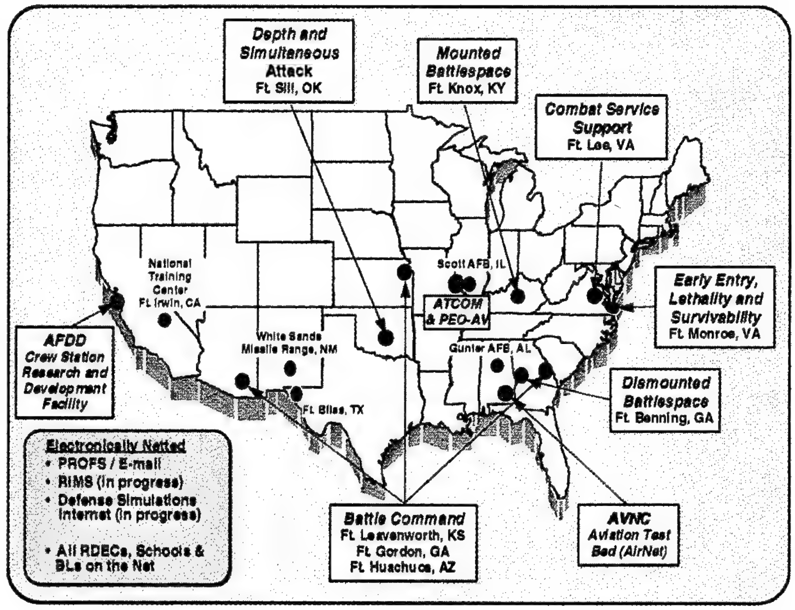


Figure 16. Aviation Connectivity to the Battle Labs - Scope and Scale.

The aviation S&T program described in this Plan supports the AAMP introduced in Section I and complies with the guidance and constraints of the DoD TAPs and the DA ASTMP. The S&T strategy and associated program is the product of the AVRDEC's In-House Review, the Annual Non-AVRDEC S&T Review and guidance received from HQDA, Office of the Assistant Secretary for Research and Technology. The aviation military need, priorities and other "user" aspects are extensively coordinated with the U.S. Army Aviation Center.

Aviation S&T Strategy Development

In keeping with modern business planning, the aviation S&T strategic vision is:

> ***"Global mission capability through Vertical Lift Technology"***

The top level investment strategy to achieve the vision is shown Figure 17. As can be noted, the end objective of the strategy is to attain new or improved operational capabilities for Force XXI by integrating affordable technologies into new rotary wing advanced concepts, fielded system upgrades and near-term fixes in the fielded fleet. Listed in the upper left block are the technology disciplines which comprise the AVRDEC's S&T program. The lower left block shows examples of the important technologies

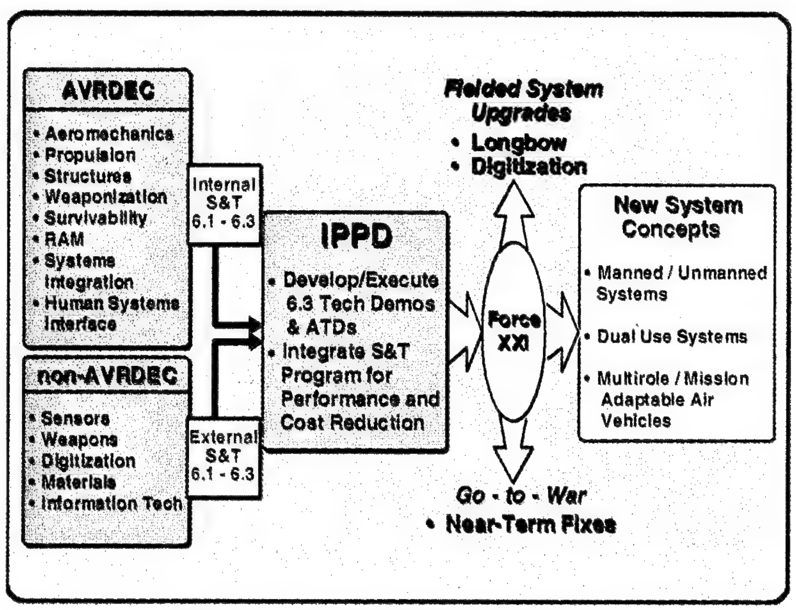


Figure 17. Aviation S&T Investment Strategy.

provided by other government agencies. Using Integrated Product and Process Development (IPPD) techniques, the products of the AVRDEC and non-AVRDEC early cycle S&T programs will be system integrated and demonstrated in a series of advanced technology demonstrations.

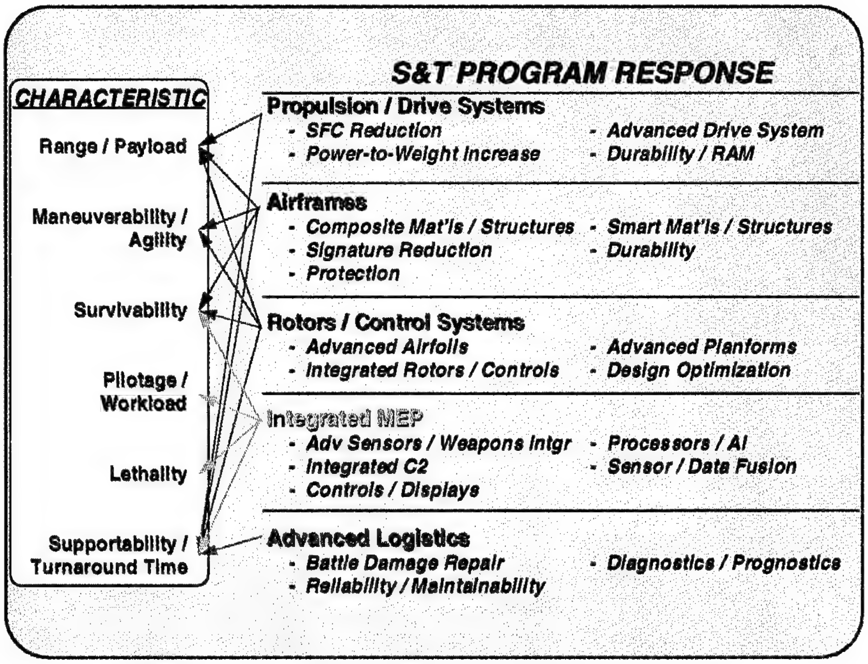


Figure 18. Aviation S&T Program in Support of Force XXI.

To support the concepts of Force XXI, future Army aviation systems discussed in Section II must be affordable and will have to operate at greater performance levels in speed, space and time. It is forecasted that, although the parameters of Force XXI are still evolving, needed improvements in aviation performance characteristics should be made. Some of the key operational characteristics that drive the strategy formulation are listed on the left side of Figure 18. The right side shows the aviation S&T program response in terms of the technology disciplines and their linkage with the applicable characteristics. Also for each technology discipline is shown some of the benefits and approaches to achieve the characteristics. In this era of continually declining resources, the AVRDEC must rely on the funded efforts of many other government agencies. Figure 19 shows some of the key agencies and their S&T contributions, which are virtually integrated in every AVRDEC technology discipline. Their greatest prominence is in the technology area of Mission Equipment Package (MEP).

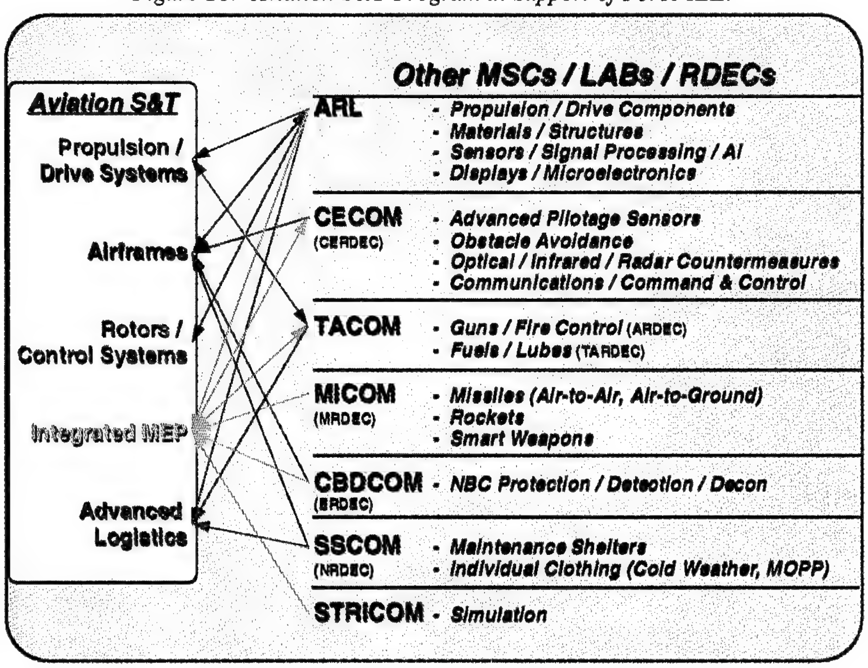


Figure 19. Aviation S&T Support - Other MSCs and RDECs

To provide guidance to the S&T community, the Army has established a set of about 200 STOs to ensure Army forces remain technologically superior to the threat and consistent with the Force XXI doctrine. A STO states a specific, measurable, major technology advancement to be achieved by specific fiscal year. The Army uses the STOs to focus and stabilize the S&T program, practice management

ASTMP No.	Title	Technology Thrust
III.D.1.	Rotorcraft Pilot's Associate (RPA) ATD	MEP - HSI
III.D.3	Advanced Rotorcraft Transmission (ART-II)	Propulsion
III.D.4	Helicopter Active Control Technology (HACT)	Aeromechanics
III.D.8.	Advanced Image Intensification (AI2) ATD	MEP - Sensors
III.D.9.	The Army's Combined Arms Weapon System (TACAWS)	MEP - Weapons
III.D.11.	Manufacturing and Structures Technology for Efficient Rotorcraft (MASTER)	Structures
III.D.12.	Advanced Helicopter Pilotage Phase I/II	MEP - Sensors
III.D.13.	Multispectral Countermeasure (MSCM) TD ATD	MEP - Sensors
III.E.8	Aviation Integration into the Digitized Battlefield	MEP - C4
IV.C.1.	Integrated High Performance Turbine Engine Technology (IHPTET)	Propulsion
IV.K.4.	Multi-Wavelength, Multifunction Laser	MEP - Sensors
CER-02	Advanced EO/IRCM & Situational Awareness	MEP - Survivability
CER-03	Air/Land Enhanced Reconnaissance & Targeting (ALERT)	MEP - Survivability
MRD-08	Low Cost Precision Kill (LCPK)	MEP - Weapons

Table IV. Aviation Related STOs.

by objectives, and provide feedback to scientists and engineers regarding their productivity and customer satisfaction. The STOs must be consistent with the current and next five years' budget. They are reviewed annually at a Joint AMC/TRADOC meeting and then reviewed and approved by the Army Science and Technology Working Group (ASTWG). The aviation (ASTMP No. III.D.) and aviation-related STOs are listed in Table IV, and are aligned with their related technology thrusts (technical discipline). The STO statements in their entirety may be found in the ASTMP Volume II.

Roadmap for Army Aviation

Figure 20 presents a summary of major technology demonstrations and S/SU/ACs that are the key elements of the aviation S&T strategy. Descriptions of the S/SU/ACs can be found in the previous Section II of this plan and descriptions of the demonstration programs are in the related technology thrust subsections. The demonstrations are designed to establish a "proof-of-principle," i.e. to serve as a test bed, validate feasibility, and reduce cost and risk for entering engineering and manufacturing development (EMD). The ATDs are large scale in both resources and complexity. They have operator/user involvement from planning to final documentation and testing in a real and/or synthetic operational environment. The ATDs have a finite schedule (five years or less) and have cost, schedule, and performance baselines in an Army Technology Demonstration Plan approved by the Office of the Assistant Secretary of the Army for Research and Technology.

Figure 20 illustrates how the Army aviation plans to use TDs and ATDs to support the development of its future aviation systems and dual use technology for the nation's rotorcraft industry. The aviation S/SU/ACs are shown at the top of the figure. The lower half of the figure shows the substantial block of demonstration programs that support the S/SU/ACs and provide opportunities for technology upgrades of fielded systems. The roadmap shows two "technology insertion windows which offer opportunities for technology application to aircraft S/SU/ACs. Technology insertions are not explicitly shown which may occur through materiel change programs for fielded aircraft such as AH-64 Apache, UH-60 Black Hawk, CH-47 Chinook, OH-58D Kiowa Warrior, and MH-60K/MH-47E SOA.

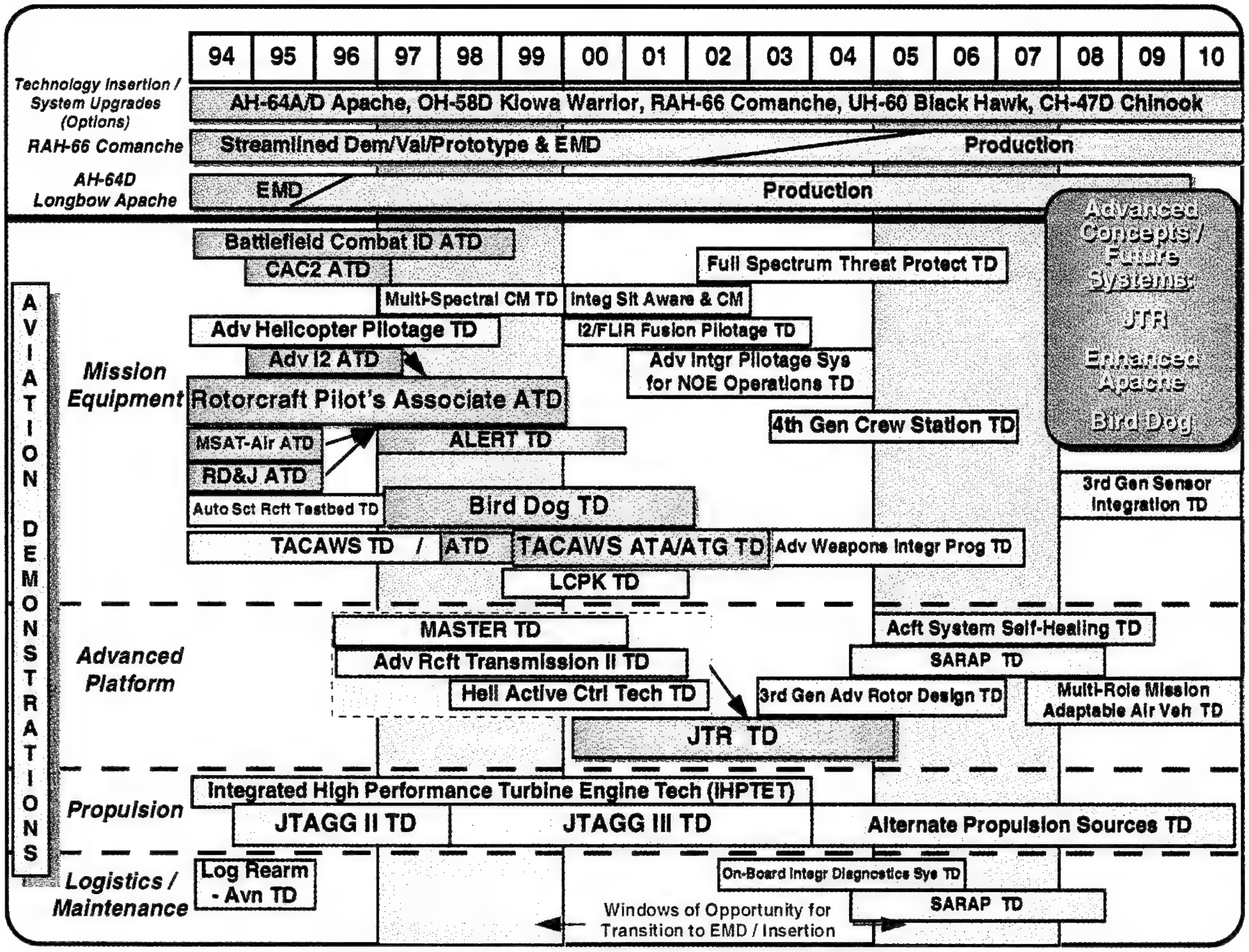


Figure 20. Aviation S&T Roadmap (from the 1995 AAMP).

The following technology thrust subsections provide a more definitive investment strategy for the aviation demonstrations categorized on the roadmap as mission equipment (sensors, weapons, survivability, communications, navigation, and human-system integration), Advanced Platform (aeromechanics, flight control, and structures), Propulsion, and Logistics/Maintenance. Each thrust subsection describes its STOs, Battlefield Dynamics OCRs adressed, technology demonstrations, accomplishments and plans. A complete crosswalk of S&T programs to the Battlefield Dynamics is at Appendix B.

AVIATION S&T DEVELOPMENT

THRUST 1: AEROMECHANICS & FLIGHT CONTROL

Requirements

Aeromechanics science and technology seeks to improve the performance of rotorcraft while reducing the noise, vibrations, and loads inherent to helicopter operation. Efforts are focused on refining analytical prediction methods and testing capabilities, on improving the versatility and efficiency of modeling advanced rotorcraft, and on achieving breakthroughs through concept applications.

Flight control technology defines the aircraft flying qualities and pilot interface to achieve desired handling qualities in critical mission tasks, synthesizes control laws that will facilitate a particular configuration achieving a desired set of flying qualities, and integrates advanced pilotage systems to the aircraft. The revolution in the power and miniaturization of computers holds tremendous promise in this field, permitting the realization of the full potential of the rotorcraft's performance envelope and maintenance of mission performance in poor weather and at night.

Since this thrust is primarily associated with the 6.2 Concept Exploration and Development, it is difficult to align these efforts directly with the OCRs. However, they have a definite impact on the design and performance of future aircraft and system upgrades which can be linked with the OCRs. In response to the ASTMP STO III,D.4, Helicopter Active Control Technology (HACT), a HACT TD has been formulated and planned for FY 98-01.

Goals

The Aeromechanics & Flight Control S&T thrust has identified several technological challenges to overcome in the next decade to impact the design, specifications, and performance characteristics of future systems, system upgrades and advanced concepts. The primary objectives are outlined in Tables V and VI. The technological challenges and the approaches being undertaken to resolve them are outlined in Figures 21 and 22.

Objectives	By 2000	By 2005
Reduce vibratory loads	33%	53%
Reduce vehicle adverse aerodynamic forces	10%	20%
Increase maximum blade loading	15%	25%
Increase rotor aerodynamic efficiency	5%	10%
Reduce acoustic radiation	4 decibels (db)	7db
Increase rotor inherent lag damping	50%	100%
Effectiveness in aeromechanics prediction	74%	84%

Table V. Objectives for Aeromechanics.

Objectives	By 2000	By 2005
Improve external load handling qualities (HQ) at night	Cooper-Harper Pilot Rating (CHPR) 4	CHPR 3
Reduce probability of degraded HQ due to flight control system (FCS) failure	50%	90%
Improve HQ at night with partial actuator authority	CHPR 4	CHPR 3
Increase exploitable agility and maneuverability	10%	15%
Reduce FCS flight test development time	30%	50%
Improve weapon-platform pointing accuracy	60%	80%

Table VI. Objectives for Flight Control.

Technology Challenge	Approach
• Accurately predict & control stall & compressibility characteristics of airfoils and impact on unsteady loads & resulting structural dynamic responses.	• Investigate influence of airfoil profile on dynamic stall in compressible flow and flow control techniques; develop concepts to apply smart materials for flow control & structural response.
• Accurately predict and control forces caused by viscous & interactional aerodynamics and separated flow.	• Enhance flowfield visual techniques using Doppler Global Velocimetry; study models' rotor wake & fuselage pressure distribution using Isolated Rotor Test System; use CFD & analyses.
• Accurately predict & control stall and compressibility characteristics of airfoils along span of rotor blades & impact on blade loading limits; Need to increase maximum outboard blade lift coeeficients.	• Develop high dynamic lift stall-free airfoils with multi-element concepts such as slats, slots, variable leading edges, or boundary layer controls.
• Accurately predict & control forces caused by viscous aerodynamics and separated flow.	• Develop reliable, validated engineering computational codes based on full-potential, vortex embedding techniques to predict rotor performance & loads in all flight regimes.
• Predict & control effect of rotor wake & blade response on unsteady aeroacoustic loads; controlling compressibility effects on advancing-blade acoustic sources & propogation phenomena is hampered by interdependence of parameters which influence noise radiation.	• Develop verified CFD code to predict wake geometry airloads & performance for rotor blades, in particular blade-vortex interaction regimes & resulting aeroacoustics.
• Identifying successful combinations of aeroelastic rotor couplings to increase damping; constraints include conflicting design requirements, rotary-wing operating regime diversity, & fail-safe reliability requirements.	• Investigate kinematic & smart structures couplings which result in less dependency on separate damping devices; utilize parametric rotor testing to substantiate prediction fidelity of marginally-damped rotor configurations.
• Solutions to multidisciplinary rotorcraft system phenomena; acquiring high-quality correlation data for validation; prediction-to-design interface for complex rotorcraft synthesis.	• Prediction effectiveness attributes defined & composed against data to determine element accuracy; metrics for improvement include quantifiable sub-element effectiveness & system integration value, such as in an IPPD simulation.

Figure 21. Technological Challenges and Approaches for the Aeromechanics Thrust.

Technology Challenge	Approach
• Knowledge of optimal rotorcraft response types (rate, attitude command/altitude hold, translational rate command) & interactions with load suspension dynamics & load aerodynamics.	• Use piloted simulation and flight test to investigate handling qualities requirements for slung loads; develop criteria for poor weather and darkness; extend efforts to address high speed flight and loads with significant aerodynamic interactions.
• Techniques for sensing onset of limits, determining appropriate actions, and cueing pilot or generating automatic interference to permit pilot to safely (but aggressively) fly rotorcraft out to limits of flight envelope.	• Use analysis and piloted simulation to develop techniques for protecting pilot from loss of control and avoiding catastrophic failures or reduced fatigue life; validate critical concepts in-flight using variable stability helicopter.
• Air vehicle math modeling and FCS design, optimization, and validation techniques; deficiencies prevent achieving desired handling qualities for advanced configurations and critical mission tasks, without time consuming iteration during test flight.	• Improve math modellingand simulation fidelity so that new aircraft actually fly as designed; improve techniques for updating math models and control laws to minimize time required to diagnose and eliminate deficiencies; for advanced fly-by-wire flight control systems develop simpler redundancy management and software V&V techniques to reduce time for making changes.
• Knowledge of optimum functional intergration of flight controls, engine fuel control, weapon systems, and pilot interface.	• Develop a viable Integrated Fire and Flight Control (IFFC) system architecture; conduct manned full-mission simulation, ground demonstration of hardware & software for airborne applications; and flight test demonstration of IFFC concept.

Figure 22. Technological Challenges and Approaches for the Flight Control Thrust.

The objective of the HACT TD (Figure 23) is to demonstrate the integration of active control technology through application of systematic, robust control law design methods and fault tolerant architecture to: improve cargo and utility class rotorcraft slung load handling qualities to a Cooper-Harper Pilot Rating (CHPR) of 4, improve weapon platform pointing accuracy 60%, reduce envelope maneuvering margins 60%, and reduce flight control system development time by 30%.

Strategy

The technology investment strategy for aeromechanics and flight control is focused on resolving these challenges. The approach is also illustrated in Figures 21 and 22. The program integrates in-house and contracted efforts, research from academia, Independent R&D and SBIR, as well as supporting S&T from the ARL. Additionally, some basic research and concept development is also transferred to and from the other services and foreign programs. The overall Aeromechanics and Flight Control S&T thrusts strategy is illustrated at Figure 24.

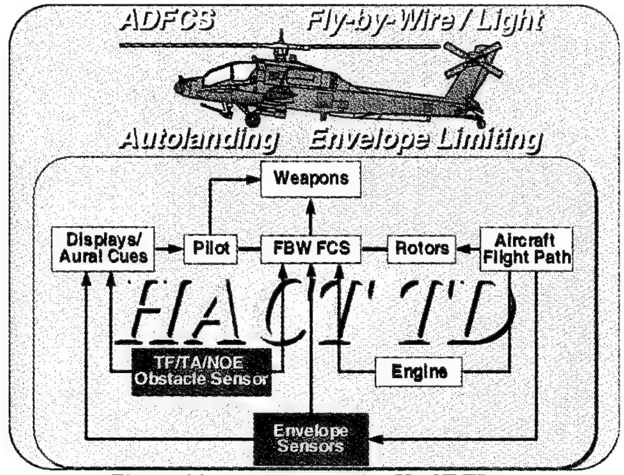


Figure 23. Architecture for HACT TD.

These efforts will be brought together and demonstrated in the HACT TD. The HACT TD

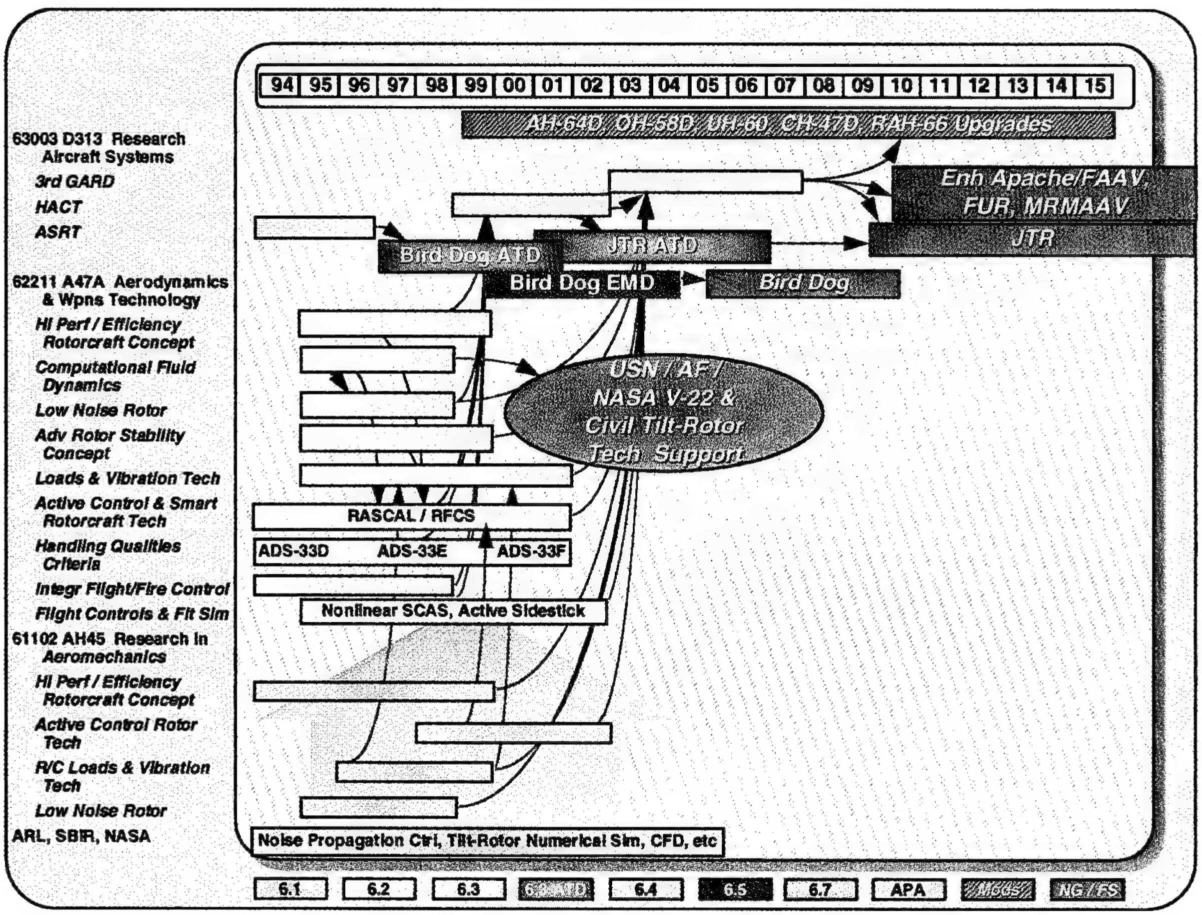


Figure 24. Aeromechanics and Flight Control S&T Strategy Roadmap.

program capitalizes on current and immediate future 6.1 and 6.2 research to demonstrate, via simulation and flight test, second generation digital fly-by-wire/light control systems, integrated fire, fuel, and flight control (IFFC), multi-mode Stability Control Augmentation System (SCAS) for carefree maneuvering. HACT will also provide the baseline handling qualities criteria for the JTR ATD, as well as supports potential system upgrades and civilian rotorcraft developments. Plans call for a follow-on effort for integration with the envisioned 3rd Generation Advanced Rotors Demonstration (3rd GARD).

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

Aeromechanics:
- Slotted rotor data analyzed for rotor application
- Dynamic stall suppression via airfoil slat evaluated
- Correlated UH-60 airloads data with analysis
- Kirchhoff rotor noise prediction formulation developed
- Computational Fluid Dynamics (CFD) system generated for entire RAH-66
- Completed High Harmonic Control Aeroacoustic Rotor Test (HART) test series in the Deutschland-Nederland Windcanal (DNW) (Germany-Netherlands Windtunnel)
- Designed and bench tested piezoelectric elevon-blade model rotor

Flight Control:
- IFFC phase II completed; 50% reduction demonstrated in aiming error, engagement timelines, pilot workload
- Developed flight test maneuvers for cargo/slung load operations
- Developed flight test maneuvers for cargo/slung load operations

During FY 95, the following program milestones were achieved:

Aeromechanics:
- Fuzzy logic research applications
- High lift airfoil design and data

Flight Control:
- Completed development of flight test maneuvers & initiated cargo/slung load helicopter handling qualities (HQ) development for hover, low speed and dense loads.
- Evaluated visual & aural cueing techniques for carefree maneuvering.
- Developed control laws for in-flight simulation model "following" capability.
- Developed hardware/software to support integration of IFFC systems in pre-selected rotorcraft for flight test demonstration.

Milestones

Major technical and program milestones in the Aeromechanics and Flight Control technology thrust area in the FY 96-01 POM period include:

FY 96 Milestones:
Flight Control:
- Continue Cargo/slung load HQ criteria development; apply control limiting for cueing to achieve carefree maneuvering.
- Initiate demonstration of full IFFC in a ground based systems integration facility.
  Initiate integration/checkout of RASCAL research flight control system.

Aeromechanics:
- Design 3rd GARD rotor tests.

FY 97 Milestones:
Aeromechanics:
- Develop HACT dynamic concepts
- Rotor dynamic and aeroacoustic loads assessment/predictive code development

Flight Control:
- Provide HQ criteria for cargo class rotorcraft slung load night operations.
- Demonstrate carefree maneuvering using control limiting/cueing techniques with neural nets.
- Complete bench demonstration of full IFFC and initiate planning and preparation for future flight test demonstration.

- Complete checkout of RASCAL research flight control system and initiate flight simulations.

FY 98 Milestones:
Flight Control:
- Flight validate flight control law synthesis methods
- Partial authority SCAS concepts
- Initiate HACT TD

Aeromechanics:
- Model rotor test with active blade control.

FY 99 Milestones:
Flight Control:
- Cargo/Slung load handling qualities criteria -- forward flight load stabilization
- Design HACT Flight Control Architecture

Aeromechanics:
- Demonstrate active swashplate stability augmentation.

FY 00 Milestones:
Flight Control:
- Complete HACT hardware & software design

Aeromechanics:
- Demonstrate low vibration concept.

FY 01 Milestones:
Flight Control:
- Hot bench integration and test of HACT components

Aeromechanics:
- Identify smart structures rotor applications.

FY 02 Milestones:
Flight Control:
- Complete HACT simulation and analysis.

Aeromechanics:
- Conduct low vibration/noise, high performance rotor tests with active control.

THRUST 2: MATERIALS, PROCESSES, AND STRUCTURES

Requirements

The Materials, Processes, and Structures thrust (MP&S) supports Army aviation needs for reduction of life cycle costs, signatures, empty weight/gross weight (EW/GW) ratio, vibration and interior noise, increased payload/GW ratio, mission range, survivability, and improved operational availability. This thrust provides Army aviation with technology solutions and options which will increase the level of performance and durability, and reduce the life cycle costs of all air vehicle platforms.

The materials sub-thrust focuses on providing materials with greatly improved properties which will provide for major capability improvements for aviation platforms. Advanced materials, such as toughened epoxies, thermoplastics, composites, new tooling, provide the potential for drastic reductions in labor costs and in operating and support costs (O&S), and increases in structural efficiency. 'Smart materials' and embedded sensor technologies will allow reduction in fabrication and O&S costs. Multifunctional capabilities of composite material systems can simultaneously incorporate structural, ballistic, and signature reduction improvements into one material system.

The processes sub-thrust provides for new understanding of the influence of material microstructure on desired performance characteristics. Processing technologies, such as textile weaving and fiber placement, curing methods, controls and sensors, process simulation and prototyping, and non-destructive analysis all contribute to the reduction of fabrication costs, O&S costs, and increase in reliability, availability and maintainability (RAM).

The structures sub-thrust focuses on maintaining structural integrity, structural design concepts, dynamic systems analysis, and crew comfort while assuring that the air vehicle system is designed to function with the rugged integrity and high performance demanded in the combat environment and retaining the simple maintainability required in the field. Structures programs demonstrate the benefits derived from

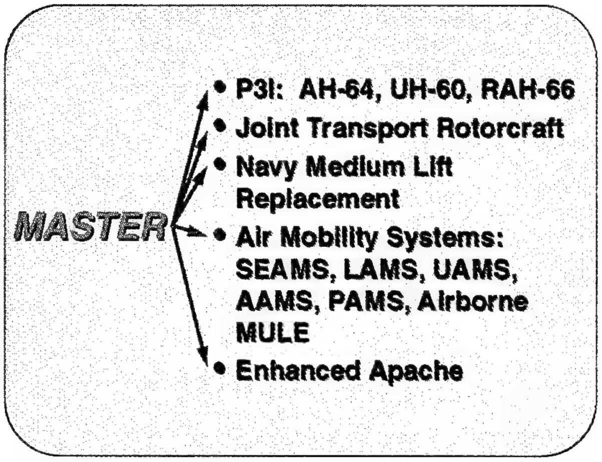


Figure 25. MASTER Technology Insertion into S/SU/ACs.

integrating advanced materials with processes into generic or prototype hardware with improved capabilities.

The 6.2 program is focused on technology for the 6.3 MASTER TD. The MASTER STO technology demonstration is motivated by our aging cargo transport aircraft fleet with range/payload limitations, and high life cycle costs. This TD will use emerging technologies to demonstrate structurally tailored, efficient, affordable and supportable airframes, robust manufacturing tooling and processes, in-flight monitoring of structural integrity, and virtual prototyping of component manufacturing through IPPD principles. MASTER technology insertion opportunities are shown Figure 25.

The OCRs supported by the Materials, Processes, and Structures thrust include aspects of the following Battle Labs: Early Entry, Lethality and Survivability; Mounted Battle Space; Dismounted Battle Space; Depth and Simultaneous Attack; and Combat Service Support.

Goals

Thrust goals have been formulated to provide

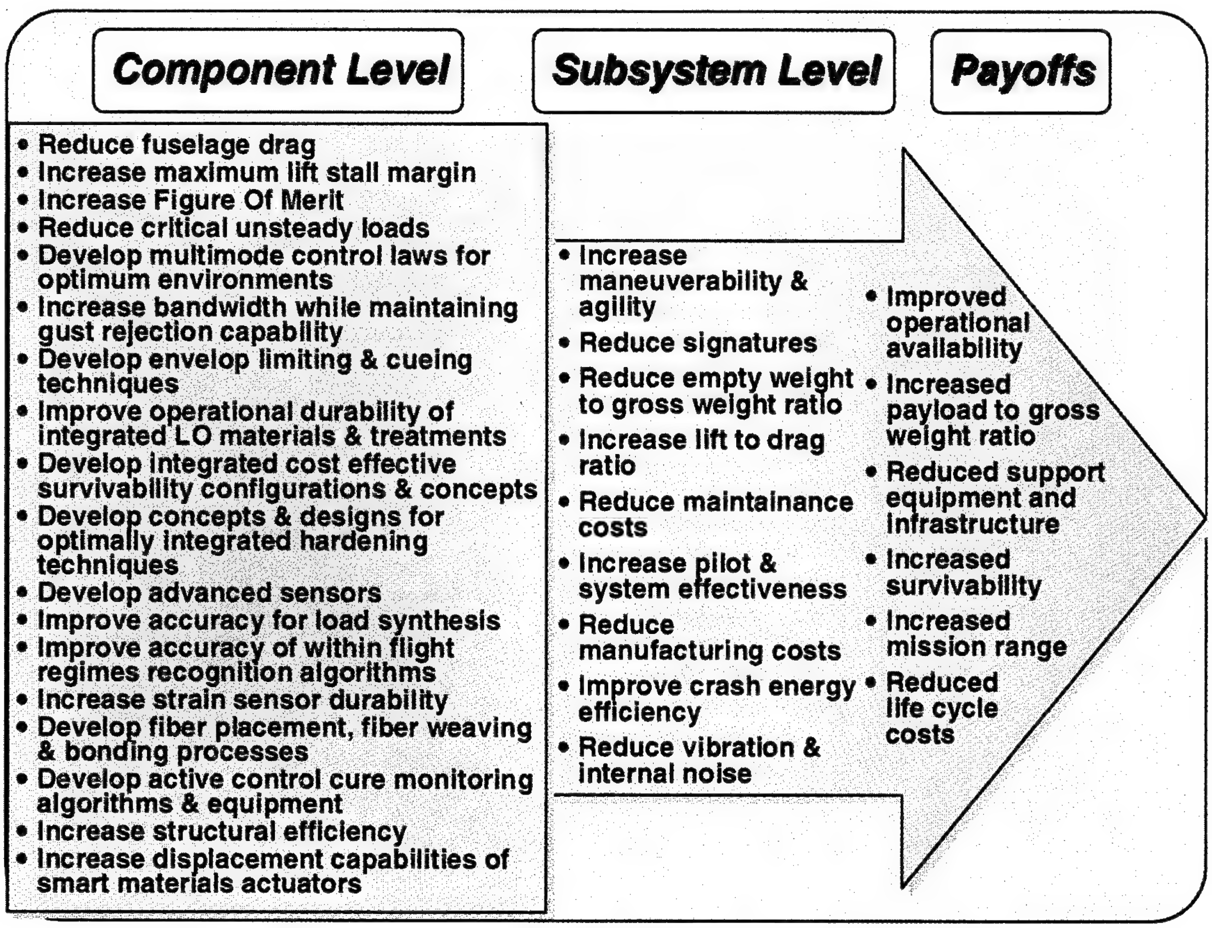


Figure 26. Hierarchy of Goals for Aviation Materials, Processes, and Structures.

the payoffs shown in Figure 26. Goal hierarchy is also shown starting with the component level, which is primarily in the RDT&E 6.2 exploratory development. The quantified goals are shown in Table VII.

Objectives	By 2000	By 2005
Accuracy of in-flight cumulative fatigue damage prediction	95%	98%
Accuracy of structural loads prediction	75%	85%
Reduce manufacturing labor hours per pound of structure	25%	40%
Increase structural efficiency	15%	25%
Increase displacement capability of smart materials actuators	300%	500%

Table VII. Structures Thrust Goals.

Strategy

The thrust strategy is based upon guidance from the AAMP, the ASTMP, and Project Reliance, and considering special interest, higher Headquarters direction, results of military conflicts and Government/ Industry technology interchanges. The life cycle technology flow from Army proponencies is shown in Figure 27.

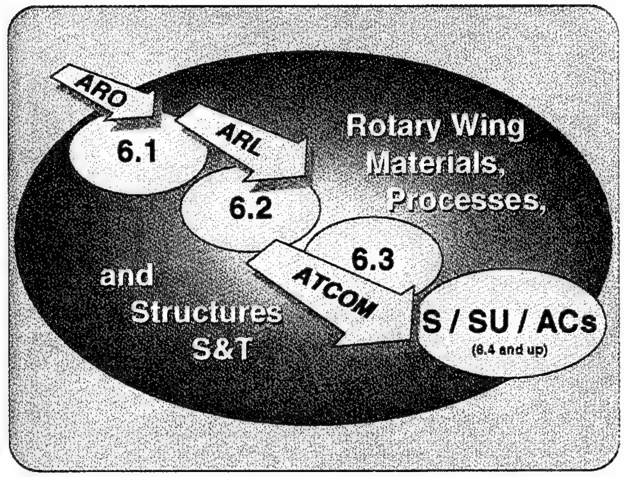


Figure 27. Life Cycle Technology Flow of the Materials, Processes, and Structures Thrust.

The AVRDEC is the Project Reliance

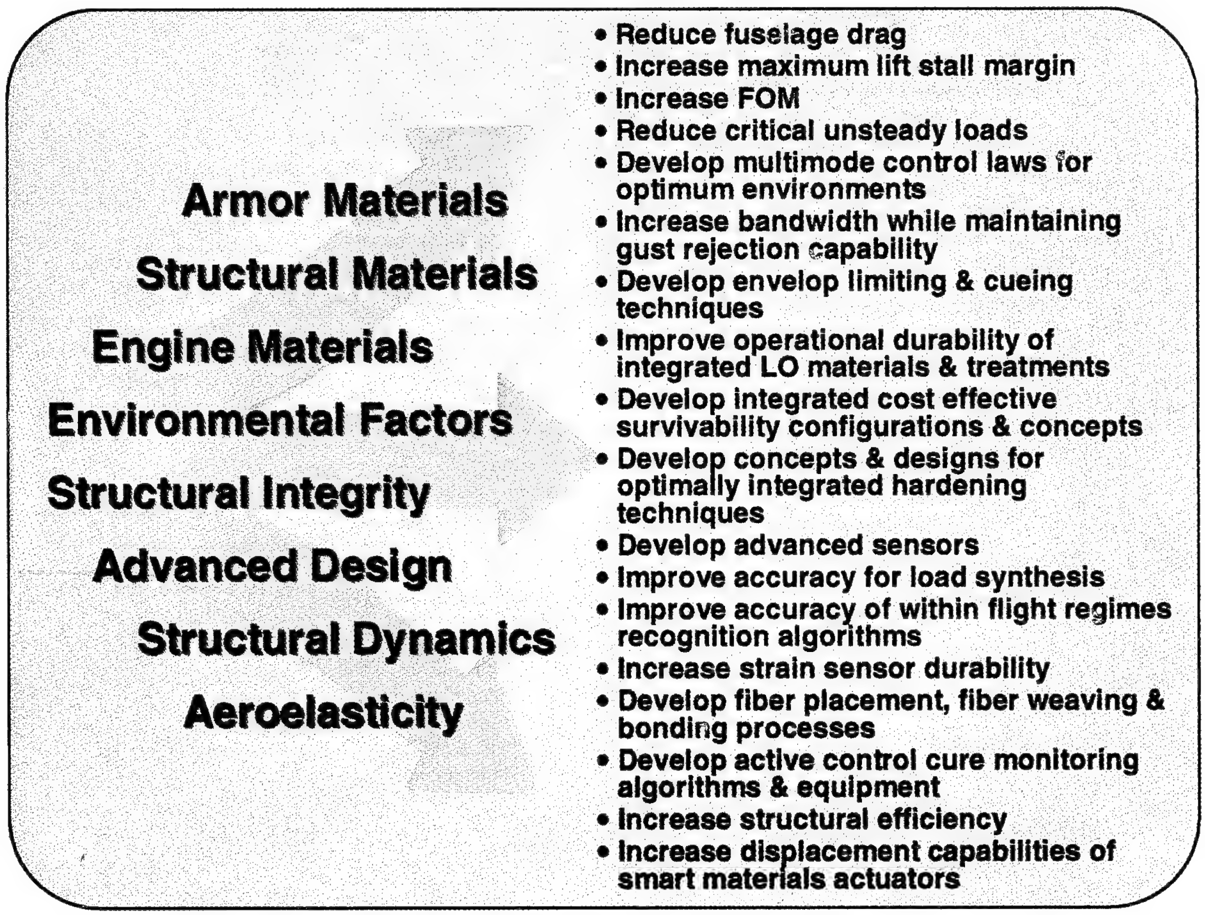


Figure 28. Primary Focus of the MS&T Program.

proponent for rotorcraft. Through the Technology Program Annex (TPA) program, the Army Research Laboratory (ARL) supports this thrust. The Vehicle Structures Directorate is the focal point for 6.1 & 6.2 structures research development. The Materials Directorate provides support for materials and processes. Support also comes from ARL's Advanced Simulation & High Performance Computing and Information Science & Technology Directorates. Active SBIR program efforts have been targeted to support the S&T program focus and the JTCG is also an active player in the thrust. There is also interaction with the Manufacturing Science and Technology program (MS&T) (see Figure 28 and Figure 40).

The rotary wing materials, processes, and structures thrust is focused on design and manufacturing for affordability and structural integrity. The thrust is responsive to the DoD Technology Area Plan (TAP) and to achieving the DoD rotary wing vehicle technology goals through careful alignment of programs with obstacles to achieving the component level technology goals. This thrust is postured to support other DoD special emphases, product improvements of fielded and developmental systems, joint multi-use transport rotorcraft (e.g., JTR), affordable aircraft acquisition, and dual-use initiatives (see Figure 29).

FY 94 and FY 95 Accomplishments

- Completed fabrication of advanced rotor blade erosion protection system and fielded for operational evaluation.
- Demonstrated reasonable correlation for synthesized versus real time load histories.
- Demonstrated 25% labor hour reduction for lay-up of low cost preforms.
- Optimized and productionized advanced

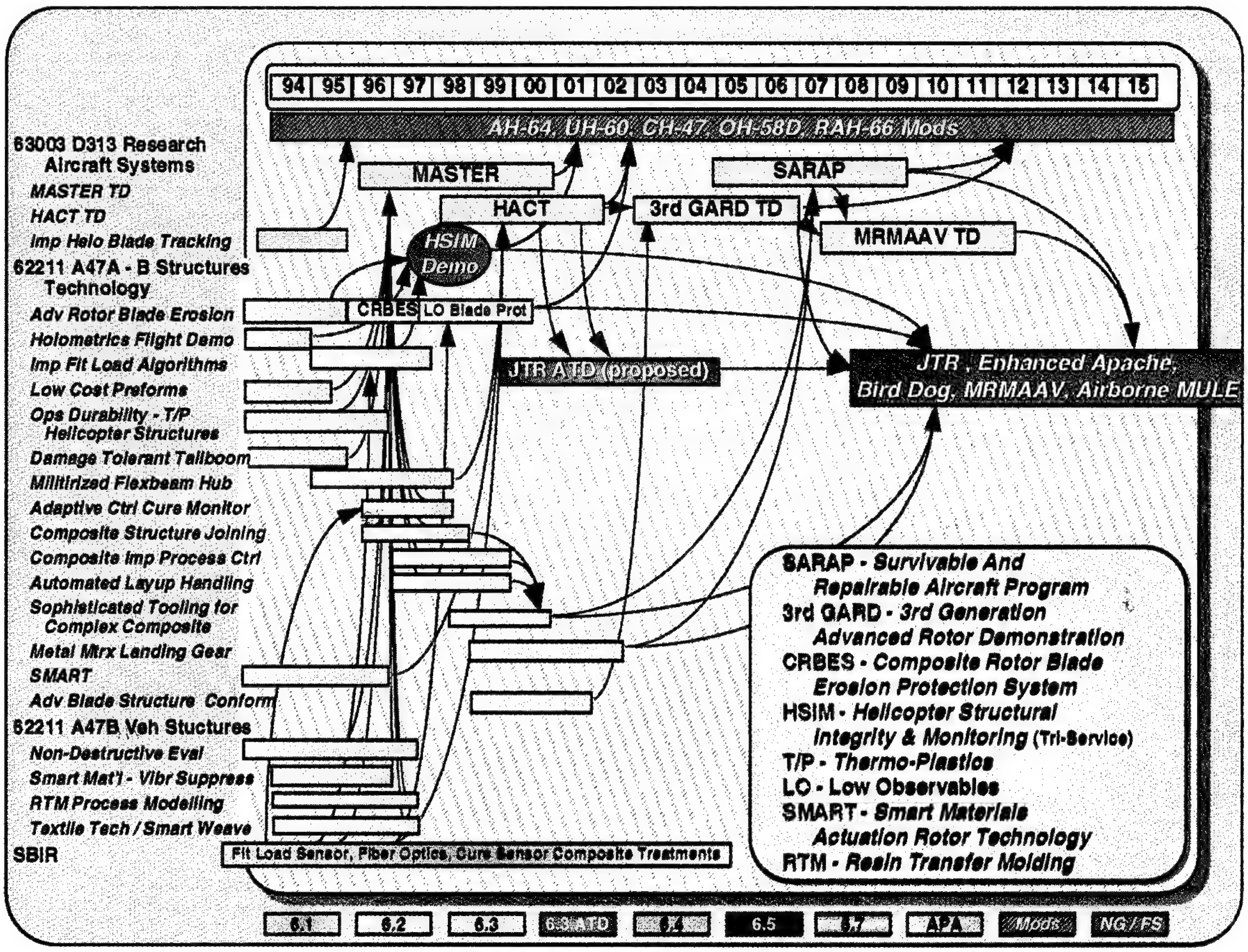


Figure 29. Aviation Structures S&T Modernization Strategy.

braiding carrier design. (SBIR)
- Completed design and tool development for thermoplastic (TP) stabilizer and fabricated TP stabilizers.
- Completed design and tooling for damage tolerant tailboom concept. (JTCG)
- Demonstrated insertion tool for embedding sensors through-the-thickness of thick laminate structures. (SBIR)
- Demonstrated through-the-thickness strain measurement with embedded fibers in dynamic environment. (SBIR)
- Demonstrated 20% improvement in structural efficiency of thick laminates with Z-pinning.
- Demonstrated the ability to resin-thermoplastic molding (RTM) representative section of RAH-66 keel beam using soft tooling and PR500 resin. (MS&T)
- Completed initial development of RTM process simulation model for 3-foot Improved Airframe Manufacturing Technology (IAMT) demonstration article. (MS&T, ARL).

Milestones:

Major technical and program milestones in the structures technology thrust area in the FY 96-01 POM period include:

FY 96 Milestones

- Demonstrate 35% labor hour reduction for material lay-up of structural stiffener preforms and 10% increased structural efficiency for "C"-channel structural stiffeners.
- Optimize and productionize advanced braiding carrier design. (SBIR)
- Develop flat modular braiding machinery with improved carriers. (SBIR)
- Fabricate three thermoplastic composite horizontal stabilizers demonstrating 48% life cycle cost reduction.
- Fabricate and ballistically test four damage tolerant tailboom cylinders.
- Demonstrate through-the-thickness fatigue strain measurement with embedded Bragg grated fibers. (SBIR)
- Demonstrate 40% ultimate traverse strength improvement in laminates with Z-fiber pinning. (SBIR)
- Demonstrate repeatable RTM process for large, complex primary structure representative of RAH-66 forward fuselage keal beam. (MS&T)
- Verify 2-D RTM process simulation for representative rotorcraft complex primary structure. (MS&T)
- Develop image processing algorithm to compute fiber volume fractions non-invasively.
- Test tailored panels and joint specimens for thinner tiltrotor wing.
- Demonstrate prototype fiber optic and dielectric embedded cure rheology sensors.
- Develop/fabricate ceramic leading edge protection system.
- Prototype Miniature In-Situ Smart Fatigue Monitor (MISSFM).
- Demonstrate image based IR inspection system.

FY 97 Milestones

- Develop improved flight load synthesis algorithms (sparse-matrix solution).
- demonstrate net braiding of "T"-section structural stiffeners in prepreg and dry preforms.
- Conduct structural element testing of uniform pressure bondline process concept.
- Conduct fatigue tests of bonded frame-to-skin structures.
- Flight test evaluation of ceramic rotor blade erosion protection system.
- Detail design manufacturing development of militarized flexbeam hub.
- Design and evaluate robust, low cost embedded rheology sensors.
- Demonstrate adaptive control cure monitoring system control algorithms.
- Identify MASTER structural, tooling and process design system architectures.
- Develop tailored structural concepts for MASTER.

- Model and simulate manufacturing processes selected for MASTER fabrication demonstration.
- Operational demo of usage monitoring on CH-47D.
- Evaluate fidelity of low cost in-situ cure rheology sensors.
- Account for 100% of flight time during structural loads prediction..

FY 98 Milestones
- Evaluate/demonstrate use of embedded adaptive control cure monitoring sensors as an in-service health monitoring system.
- Integrate fiber optic strain/load sensors into basic structure.
- Demonstrate primary bonding/advanced joining of major structural assembly.
- Structurally test extensively bonded primary structures.
- Element fabrication for verification/ validation of MASTER processes, materials and M&S.
- Static/fatigue testing of MASTER representative structural elements/coupons.
- Complete preliminary design phase of MASTER: demonstrate performance of synthetic structural, tooling and process design aids (KBS and ES) in system architecture.

FY 99 Milestones
- Demonstrate extensive use of in-situ/embedded sensors for process control and in-service health monitoring.
- Complete detailed design phase of MASTER.
- Demonstrate efficient, affordable, supportable advanced airframe structural concepts in MASTER.
- Fully verify and validate MASTER processes M&S.
- Develop heat transfer analysis of a compound curvature tool and determine optimum heating method for optimal curing heat flux.
- Fabricate critical subsections for MASTER TD.

FY 00 Milestones
- Conduct MASTER TD structural performance, structural integrity, inspectability and reparability tests and demonstrations.
- Demonstrate tailored heat input to tool surfaces on sub-scale and full-scale components.
- Fabricate critical subsections for MASTER TD.
- Complete detailed design of advanced rotor blade structural configuration and design support tests of critical components.

FY 01 Milestones

- Transition MASTER concepts to JTR ATD.
- Demonstrate stiffness, weight benefits of metal matrix composites in landing gear applications.
- Complete full-scale fatigue test and whirl tower tests, and producibility analyses of advanced rotor blade structural configuration.
- Whirl tower demonstration of hybrid actuator concepts.

FY 02 Milestones

- Fabricate metal matrix landing gear shock struts and fuselage attachment fittings.
- Conduct metal matrix landing gear drop tests.
- Demonstrate smart materials applications to rotor actuators for active control.

THRUST 3: PROPULSION

Requirements

The Propulsion thrust answers Army aviation needs for reduction of life cycle costs, EW/GW ratio, vibration and interior noise, increased payload/GW ratio, mission range, and improved operational availability. The engine, transmission and drive train sub-thrusts provide Army aviation with technology solutions which will increase the level of performance of systems supported. Engine technology efforts focus on improving aircraft powerplant performance relative to power-to-weight ratio, specific fuel consumption, higher allowable internal temperatures, reliability and maintainability, etc. Transmission technology efforts are aimed at reducing component weights, vibration, friction and thus stress on the airframe with lower power requirements, improved and simplified maintainability, and increased reliability. Drive train technology efforts focus mainly on reduction in vibratory stress and improvements in reliability and maintainability.

The major effort in the 6.2 engine technology program concerns participation in the Joint Turbine Advanced Gas Generator (JTAGG) technology demonstrations which are structured to be compatible with the goals of the Integrated High Performance Turbine Engine Technology (IHPTET) initiative, which is a three-phased tri-Service, ARPA and NASA effort with major milestones in 1991, 1997 and 2003. The JTAGG I+ effort was completed in 1994 and its goals are an interpolation of the 1991/1997 IHPTET goals. The specific JTAGG I+ goals achieved include a 25 percent reduction in fuel consumption and a 60 percent increase in power-to-weight ratio. Follow-on JTAGG II and III efforts address the 1997/2003 IHPTET goals. A full engine demonstration of the improvements in gas turbine technology resulting from the JTAGG program will be conducted as required to be compatible with S/SU/AC requirements (see Figure 30). The results will be improvements in performance, efficiency, and power-to-weight ratio over current production engines. The demonstrations will incorporate advanced materials and materials processing, simulation and modeling, CFD, and manufacturing science. Army participation in the joint initiative includes research programs to investigate and demonstrate:

- advanced performance high pressure ratio centrifugal compressors
- innovative inlet protection systems
- advanced centrifugal compressor stages
- composite shafts
- innovative turbine engine secondary flow concepts
- flight weight magnetic bearing controls
- low inertia fabrication and testing
- non-intrusive ignition systems
- ceramic matrix composite (CMC) turbines
- advanced technology combustors electromagnetic interference or pulse (EMI/EMP) insensitive fuel controls

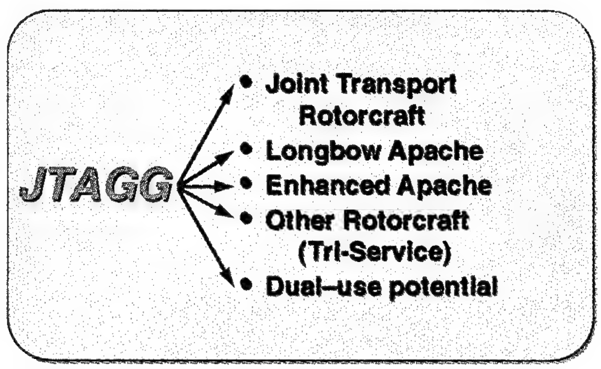


Figure 30. JTAGG Technology Insertion into S/SU/ACs.

The Advanced Rotorcraft Transmission (ART) II Technology Demonstration (97-00) incorporates key emerging material and component technologies for advanced rotorcraft transmissions and makes a quantum jump in the state-of-the-art. The ART II TD will survey applicable ART I (completed in FY 92) component technologies and proposed concepts and will integrate the more promising ones into selected transmission/drive subsystem demonstrators. Advanced concepts such as split torque, split path, and single planetary transmissions will be considered with advanced material applications and component designs to

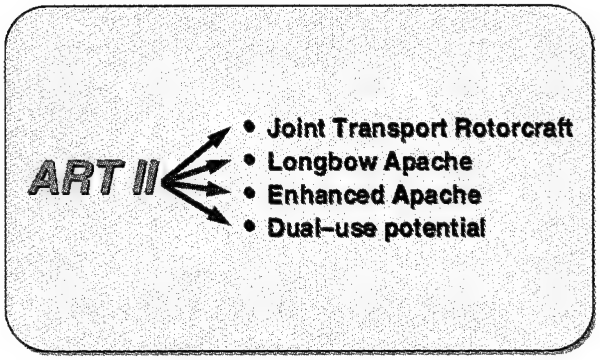


Figure 31. ART II Technology Insertion into S/SU/ACs.

demonstrate lighter, quieter, threat tolerant, more durable, reliable and efficient drivetrain subsystems. ART Phase II will demonstrate a major advance in transmission system technology through the integration of emerging technologies in materials, structures, mechanical components, dynamics, acoustics, lubrication, and manufacturing processes. Using modern production and developmental aircraft as a base, ART Phase II will demonstrate through design, fabrication and test a major subsystem/module incorporating advanced component technologies from ART I, IR&D and 6.2 Tech Base which can be transitioned into upgraded and growth fleet aircraft while raising the state-of-the-art for future military and commercial aircraft (see Figure 31).

Goals

Thrust goals have been formulated to provide the payoffs shown in Figure 32. Goal hierarchy is also shown starting with the component level, which is primarily in the RDT&E 6.2 exploratory development.

Strategy

Thrust strategy is based on guidance from the AAMP, the ASTMP and Project Reliance; considering special interest, higher headquarters direction, results of military conflicts and government/industry technology exchanges. The

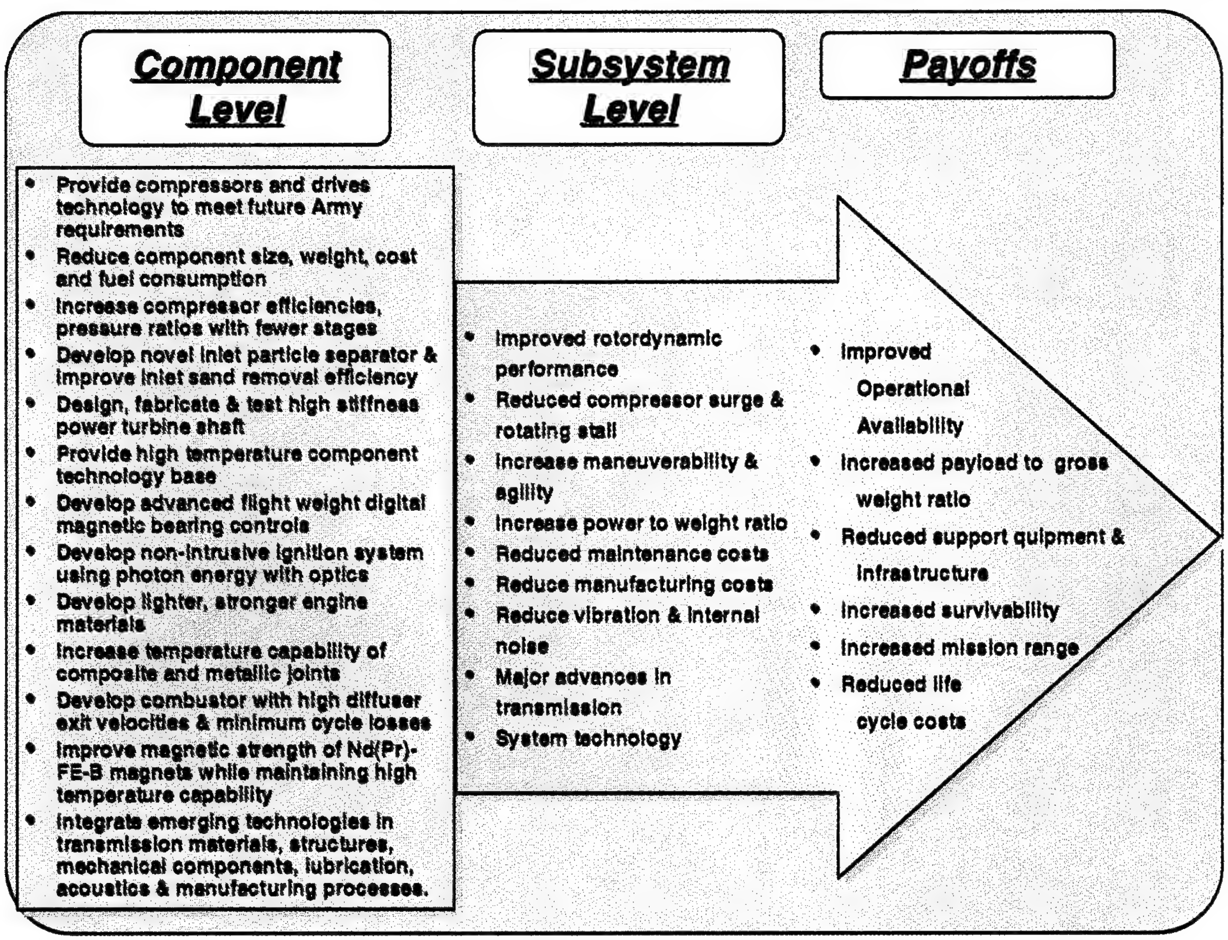


Figure 32. Propulsion Thrust Hierarchy of Goals.

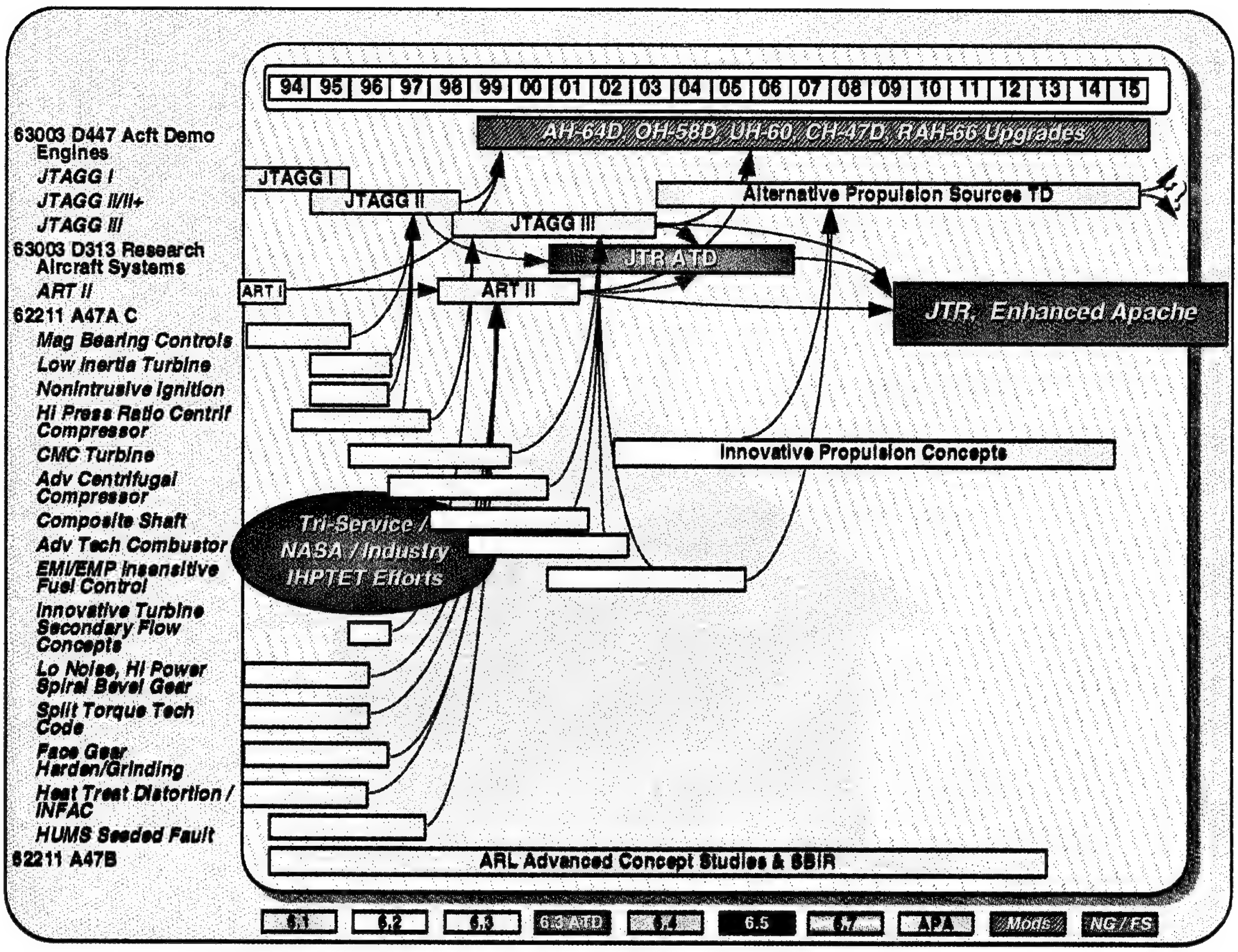


Figure 33. Aviation Propulsion and Drive Systems S&T Investment Strategy.

roadmap for the propulsion and drive systems thrust is shown in Figure 33.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Completed analysis of Innovative Inlet Protection System (IPS).
- Completed aero design of advanced performance high pressure ratio centrifugal compressor.
- Engine test of Organic Matrix Composite (OMC) inlet housing in JTAGG
- Initiated mechanical and rig designs of advanced performance centrifugal compressor.
- Initiated fabrication of low-inertia turbine.
- Completed tests of non-intrusive ignition design and sea level rig test.
- Completed adaptive lubrication system analysis and defined optimum configuration.
- Completed flight weight magnetic bearing detailed design, fabrication and controls test - achieved 36,000 rpm speed.
- Completed spin test of low inertia turbine and fabrication of high cooling effectiveness airfoils.

During FY 95, the following program milestones were to be achieved:

- Surge control for turboshaft engines Phase I SBIR distributed inlet injection determined to be optimum surge and stall control method.
- High-gain air valve using piezo-electric actuation designed.

- Designed distortion suppression system to handle air pressure gradients surrounding engine inlet.
- Demonstrated Ceramic Matrix Composite (CMC)-to-Metallic joints up to 600 °C utilizing active brazing techniques.
- Established feasibility of variable residence time (VRT) combustor concept.
- Completed detailed VRT combustor design and engine cycle analysis.
- Dual airblast injector for small gas turbine engines - completed CFD analyses for nozzle redesign, screening injector tests, fabrication of combustor nozzles and test in annular rig.

Milestones:

Major technical and program milestones in the propulsion technology thrust area in the FY 96-01 Program Objective Memorandum (POM) period include:

FY 96
- Initiate aero testing of advanced centrifugal compressor.
- Complete concept evaluation and initiate demonstration of secondary flow concepts.
- Initiate CMC Turbine Program.
- Demonstrate improved non-intrusive ignition capability.
- VRT Combustor hardware fabrication and three-dimensional (3D) computer modeling.
- Initiate JTAGG II gas generator test.

FY 97
- VRT Combustor annular rig test.
- Optimize JTAGG II gas generator components for final demonstration.
- ART II - initiate planning and procurement.

FY 98
- Demonstrate IHPTET II goals.
- Define ART II system configuration and requirements.
- Detailed design of ART II subsystem/module.
- Initiate JTAGG Phase III.

FY 99
- ART II - test minimum number of components to fabricate subsystem hardware.
- Continue JTAGG III.

FY 00
- ART II - conduct durability and other testing.
- Continue JTAGG III.

FY 01
- Complete ART II TD.
- Continue JTAGG III.

THRUST 4: MISSION EQUIPMENT PACKAGE (MEP)

Requirements

The MEP thrust is the system integration of those technologies essential to safe flight and effective mission accomplishment. Sometimes called the "warfighting" technologies, the core MEP technologies are sensors, weapons, communications, navigation, survivability and Human Systems Interface (HSI). Past products of this thrust successfully demonstrated themselves in Desert Storm including the AH-64 Apache's Hellfire antitank missile, the OH-58D Kiowa Warrior's Mast-Mounted Sight and the numerous items of ASE. The aviation related DoD TAPs that apply to the MEP thrust are: Sensors; Conventional Weapons; HSI; Electronics; and Command, Control and Communications.

Like modern fixed-wing aircraft, the trend in military and civilian helicopters is towards more integrated/automated cockpits, shared sensor processing and integrated MEP functions. The add-on "black box" or subsystem approach of the past has been displaced by the system integration approach which provides a total effective weapon system while ensuring optimum human/machine interface for minimum crew workload and space, weight and power requirements. The aircraft systems integration of MEP technologies is essential to a modern system operating at NOE

ASTMP No.	Title	Subthrust	Proponent
III.D.1.	Rotorcraft Pilot's Associate ATD	HSI	AVRDEC
III.D.8.	Advanced Image Intensification (AI2) ATD	Sensors	CERDEC
III.D.9.	The Army's Combined Arms Weapon System (TACAWS)	Weapons	MRDEC
III.D.12.	Advanced Helicopter Pilotage Phase I/II	Sensors	CERDEC
III.D.13.	Multispectral Countermeasure (MSCM) ATD	Sensors	CERDEC
IV.I.5.	Objective Crew Served Weapon (OCSW)	Weapons	ARDEC/JSSAP
IV.K.4.	Multi-Wavelength, Multifunction Laser	Sensors	CERDEC
III.E.8.	Aviation Integration into the Digitized Battlefield	C4	CERDEC
MRD-08	Low Cost Precision Kill (LCPK)	Weapons	MRDEC
CER-02	Advanced EO/IRCM & Situational Awareness	Survivability	CERDEC
CER-03	Air/Land Enhanced Reconnaissance & Targeting	Survivability	CERDEC

Table VIII. Aviation Related MEP STOs.

during night and adverse environmental development of the MEP technologies of the many supporting government agencies such as MRDEC, ARDEC, CERDEC and ARL. This reliance is evident by Table VIII which shows that nearly all the MEP related STOs have, as a proponency, another agency other than the AVRDEC. The sole exception is the Rotorcraft Pilot's Associate (RPA) STO which is a MEP integration effort focused on the information overload facing today's aviator. The STOs can be viewed in their entirety in Volume II of the ASTMP. The variety and versatility of MEP technology products apply to all Battle Labs except CSS.

Goals

The technology goals of the MEP thrust area are derived from the STOs, the projected needs of the 21st century as recommended by the STAR 21 study and the operational capability requirements projected for Force XXI. As shown in Figure 20, Roadmap for Army Aviation, the Army has planned and funded a large block of MEP technology demonstration programs. The many MEP technology goals are best represented by viewing them in conjunction with their applicable technology demonstration program as shown in Table IX.

Strategy

The strategy for the MEP technology thrust is focused on the six subthrusts shown in Figure 34. The subthrust products will be demonstrated through simulation, and ground and flight tests to substantiate the feasibility of their projected operational payoffs. The roadmap for the MEP technology thrust is shown in Figure 36. The major ATDs and TDs are shown in brown and tan on the top half of the figure and other supporting TDs are shown in light blue on the bottom half. The program linkages between demonstrations are shown along with the planned technology insertions to aircraft system upgrades and future advanced concepts. Not shown are the extensive RDT&E 6.1/6.2 research and exploratory development programs conducted by the many supporting laboratories which provide the enabling component technologies that precede the TDs/ATDs.

The top priority effort in the MEP technology thrust, as well as the entire aviation S&T program is the Rotorcraft Pilot's Associate (RPA) ATD (Figure 35). The objective of this MEP integration program is to establish revolutionary improvements in combat helicopter mission effectiveness through the application of artificial intelligence for cognitive decision aiding and the integration of advanced pilotage sensors (i.e., AHP), target acquisition (MSAT-Air), armament and fire control (TACAWS/ AWIP), communications (CAC2), cockpit

Title	Goals	Description
Rotorcraft Pilot's Associate (RPA) ATD	reduced mission losses, increased targets destroyed, reduced mission timelines	Integration of advanced MEP with high speed data fusion processing and cognitive decision aiding expert systems
Advanced Image Intensification ATD	increased visual acuity and FOV, integrated symbology, improved user interface	Next generation night vision goggles with advances in displays, image intensification, optics and human factors
Battlefield Combat Identification (BCID) ATD	reduced fratricide	Demonstrate target ID techniques with situational awareness during ATA & ATG
Combined Arms Command & Control (CAC^2) ATD	real time force synchronization, shared situation awareness	Simulate/demo capability of ground and air vehicles to share common battlefield picture
Multi-Spectral Countermeasures (MSCM) ATD	defeat imaging infrared missiles	Demo an advanced low cost coherent jammer to protect helicopters against I2R SAMs
Advanced Helicopter Pilotage (AHP) TD	increased safety/awareness, reduced pilot cognitive workload, enhanced terrain flight	Night/adverse weather pilotage system to visually couple the pilot to the terrain flight environment
Advanced EO/IRCM and Situational Awareness TD	detect/jam IR homing missiles	Demo advanced missile warning for LO platforms and advanced CM against precision guided munitions
Air/Land Enhanced Reconnaissance and Targeting (ALERT) ATD	search on the move, improved target recognition/ID, longer range targeting	Flying testbed of automatic target acquisition suite which synergistically processes target features from 2nd gen FLIR and laser sensors
I2/FLIR Fusion Pilotage TD	increased mission effectiveness, increased survivability	Demo image fusion upgrades to the baseline Comanche dual spectrum (I2/IR) pilotage sys
Autonomous Scout Rotorcraft Testbed (ASRT) TD	increased targets destroyed increased survivability	Demo small, semi-autonomous UAV VTOL aircraft to perform reconnaissance mission
Bird Dog TD	reduced crew workload, increased survivability	Demo teaming of a manned helicopter and an unmanned air vehicle to perform missions
The Army Combined Arms Weapon System (ATA/ATG) TD	combat versatility, engagement in clutter environment	Demo helicopter integration of a lightweight, fire-and-forget, multi-role missile system
Objective Crew Served Weapon (OCSW)	increased door gun lethality, reduced weapon weight	Demo ultra-lightweight crew served weapon (applicable to UH/MH-60 and MH-47)
Low Cost Precision Kill (LCPK)	reduce costs, low collateral damage	Demo cost and operational feasibility of guided 2.75-inch rocket
Advanced Weapons Integration Program (AWIP)	combat versatility, tailorable levels of lethality	Demo helicopter integration of advanced weapons and target acquisition technologies
Full Spectrum Threat Protection (FSTP) TD	increased survivability, optimized mission routes/tactics	Demo synergistic integration of signature reduction, advanced EW and decision aiding technologies against advanced threats
4th Generation Crew Station TD	increased pilot effectiveness	Demo next generation of air vehicle crew station architecture
Advanced Integrated Pilotage System (AIPSYS) for Nap-of-the-Earth (NOE) Operations TD	increased survivability, reduced mission timelines	Demo advanced highly integrated pilotage system (navigation, imaging, active & passive sensors) for safe NOE operations in day, night and adverse weather

Table IX. MEP Technology Demonstrations.

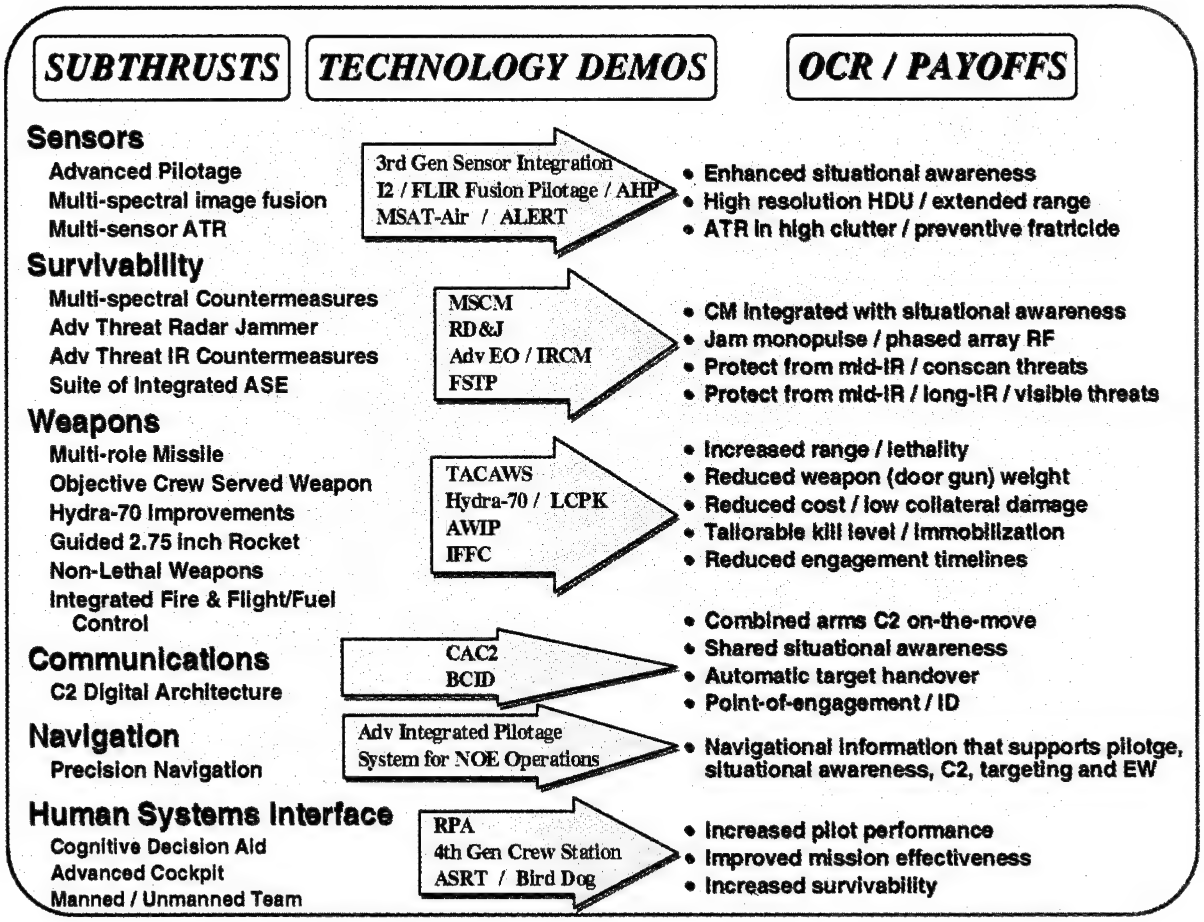


Figure 34. Focus of Aviation MEP Subthrusts.

controls and displays, navigation, survivability (RD&J) and flight control technologies. The RPA will expand aviation's freedom of operation, improve response time for quick reaction and mission redirect events, increase the precision strike capability for high value/short dwell-time targets, and increase day/night, all weather operational capability.

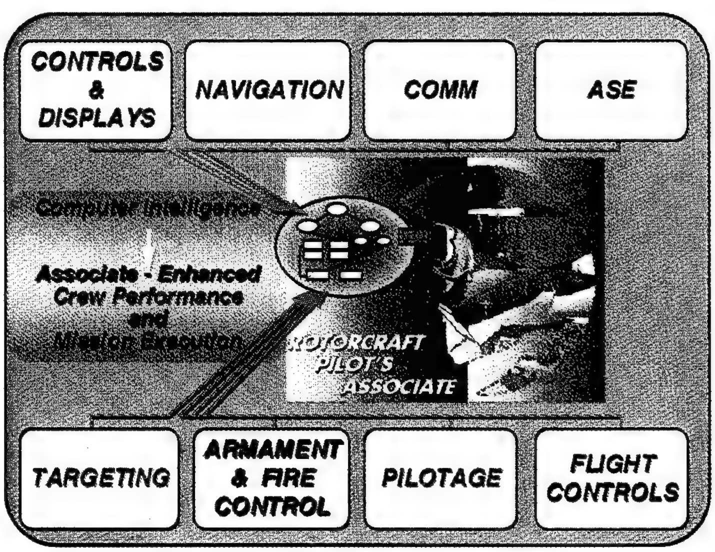


Figure 35. Rotorcraft Pilot's Associate.

The UAV recommendations of the STAR 21 study triggered the formulation of the Bird Dog initiative and its predecessor Autonomous Scout Rotorcraft Testbed (ASRT) TD. These efforts will demonstrate the use of a team composed of a manned helicopter and a vertical tyake-off and landing (VTOL) UAV with a sensor suite to perform aviation missions. The reduced level of crew workload, combined with UAV autonomy, will provide an enhanced warfighting capability and improved survivability.

Supporting these major efforts are several programs developing the necessary

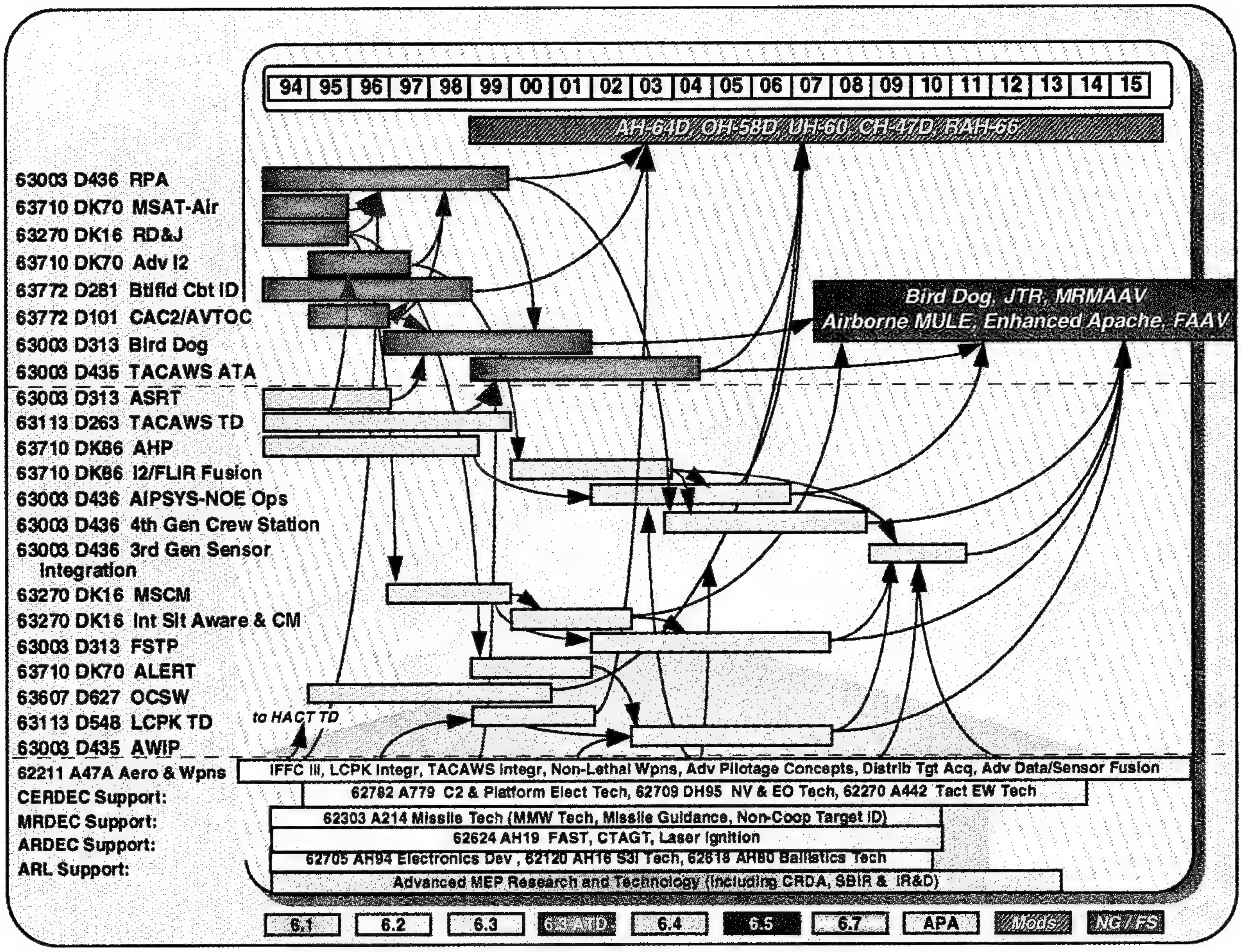


Figure 36. Aviation Mission Equipment Package S&T Roadmap.

modeling, simulation, and human system interface tools and technology. These include the Crew Station Research and Development Facility (CSRDF), MIDAS, helmet mounted displays (HMD) symbology Aeronautical Design Standards (ASD), the UH-60 System Testbed for Avionics Research (STAR), and ARL's human figure model (JACK).

In the weapons area, the major efforts are focused on TACAWS (Figure 37) , Low Cost Precision Kill (LCPK) Weapon System, Objective Crew Served Weapon System (OCSW), and interim system improvements to the Hydra 70 family of 2.75-inch rockets. The TACAWS TD and ATD objective is to develop and demonstrate a technology base necessary to build a multi-platform, multi-target, multi-mission extended range (beyond 7 km) fire-and-forget missile compatible with TOW and Hellfire family of launchers. The concept is to develop lock-on-after-launch (LOAL) technology through special signal processing, advanced ATR algorithms, and man-in-the-loop (MITL) with RF datalink. Six

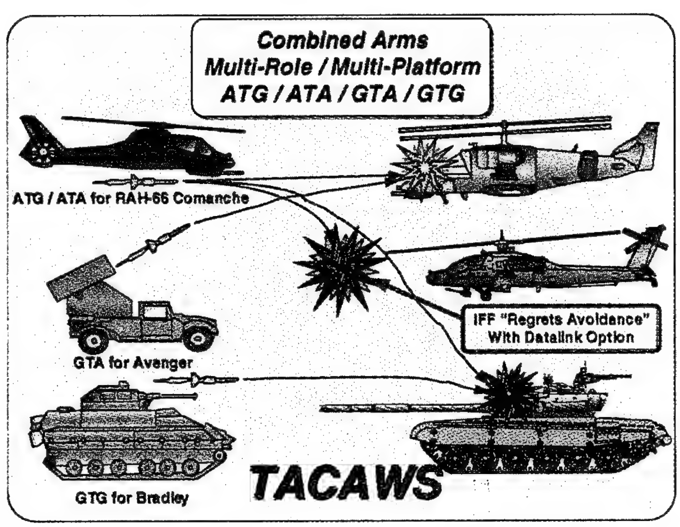


Figure 37. TACAWS Concept.

prototypes seekers and five missiles will built in support of the initial ground-based TD. Eight to ten more prototypes will then be built in support of the ground and airborne ATDs. The TACAWS effort is led by the MRDEC.

The LCPK 2.75-inch Guided Rocket concept, also managed by MRDEC, would employ a strapdown retrofit guidance and control package for Hydra 70 2.75-inch rocket application as a solution to the Army aviation Advanced Precision Kill Weapon System (APKWS) Mission Need Statement. The APKWS requirement became apparent after lessons learned during investigations of Desert Storm actions revealed that a large number of Hellfire engagements had been made against non-tank targets. Military Operations in Urban Terrain (MOUT) activities in Panama, Somalia, and Haiti have also indicated a need for an air-to-ground (ATG) LCPK capability that is smaller, less costly than Hellfire, and provides point target accuracy to minimize collateral damage in MOUT operations. The LCPK would take advantage of existing Army rotorcraft target acquisition and designation systems (AH-64 TADS and OH-5D Kiowa Warrior MMS), using a LOAL seeker similar to a miniature Copperhead. This strapdown guidance and control packages are being developed under the on-going ARPA Small Low-cost Interceptor Device (SLID) and Army 120-mm Precision Guided Mortar Munition (PGMM) programs. The LCPK concept is also being investigated for applications to Navy ship-board defense, air defense, and will be included in the weapons mix in the RPA ATD man-machine fire control techniques analysis for mission effectiveness and survivability. In the interim, the Hydra 70 Rocket Management Office at Rock Island has proposed a SIP for the family of 2.75-inch rockets to improve lethality.

The Joint Service Small Arms Program (JSSAP) Office has funded the ARDEC's OCSW program to demonstrate an ultra-lightweight two-man portable crew served weapon leading to the next generation crew served weapon system. The OCSW technology program is an approved STO with a potential to replace the door guns on UH-60, CH-47D, MH-60K, and MH-47E aircraft.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Completed RPA conceptual design, including functional requirements definition, software code, estimates, hardware architecture (build A), and interface design and control.
- Initiated TACAWS TD Program including System Design Phase. Completed hardware design. Began hardware fabrication.
- Initiated Advanced Helicopter Pilotage (AHP) TD and ASRT TD.
- Initiated joint program with MICOM for LCPK Rocket concept.
- Initiated Non-Lethal Weapons concepts for rotorcraft (SBIR)

During FY 95, the following program milestones were to be achieved:

- Complete RPA Preliminary Design Phase (Build B and 1) and initiate Detailed Design Phase.
- Complete TACAWS system design and conduct breadboard fabrication/test. Began tower captive flight test (CFT) and hardware in the loop (HWIL) simulation/test. Began prototype missile hardware fabrication.
- Complete MSAT-Air ATD demonstration of fusion of multiple sensors and processor modules with advanced algorithms in an automated target acquisition suite.
- Complete Radar Deception and Jamming (RD&J) ATD of enhanced aircraft survivability/lethality through integration of avionics and advanced ASE sensors.
- Initiated Air-to-Air Starstreak (ATASK) simulation, analysis, and integration design.
- Completed EELS BL funded joint MRDEC/ AVNC LCPK concept evaluation program.
- Began prelimianary design of Integrated Fire and Flight/Fuel Control (IFFC) Phase III.

- Completed HMD symbology database design.
- Added new single-user interface to MIDAS; demonstrated benefit to NASA High Speed Civil Transport and Civil Tiltrotor programs and Army Air Warrior.

Milestones

Major technical and program milestones in the MEP technology thrust area in the FY 96-01 POM period include:

FY 96 Milestones:

- Complete the CAC2 ATD of the capability of ground and airborne vehicles to share common battlefield picture including situation awareness and target reporting.
- Complete the ASRT TD of a small, semi-autonomous VTOL aircraft performing a surveillance/reconnaissance mission.
- Conduct ATASK separation flight testing.
- Continue RPA detailed design (System Builds 2 and 3) and initiate RPA simulation evaluations.
- Complete TACAWS missile hardware fabrication. Continue CFT/HWIL tests.
- Initiate LCPK STO. Complete LCPK requirements analysis and critical component prototyping.
- Complete R&D of MIDAS cognitive models/analysis tools.

FY 97 Milestones

- Continue RPA detailed design (System Builds 4 and 5) and RPA simulation evaluations.
- Initiate Multi-Spectral Countermeasures (MSCM) TD to demonstrate an advanced technology, low cost coherent jammer to protect helicopters against imaging IR guided surface-to-air missiles (SAMs).
- Initiate Bird Dog TD to demonstrate use of a team composed of a manned helicopter and a UAV to perform aviation missions.
- Initiate ALERT and Multispectral Countermeasures ATDs.
- Conduct IFFC hardware & pilot in the loop simulation demonstration.
- Complete TACAWS CFT/HWIL tests. Conduct HWIL plus digital simulations for LAM using BDS-D with virtual platform and missile. Conduct ground platform integration, live fire tests, and final design neckdown.
- Complete LCPK component prototyping and begin CFT/HWIL tests.
- Submit draft HMD symbology ADS to industry review.
- Formally evaluate MIDAS workstation and model performance.

FY 98 Milestones

- RPA Flight tests begin.
- Proposed RPA simulation Battle Lab Warfighting Experiment (BLWE).
- Bird Dog simulation demonstration and flight
control tests.
- Complete AHP TD.
- Complete TACAWS platform integration design.
- Complete LCPK CFT/HWIL tests.
- Demonstrate IFFC hardware/software.
- Initiate HMD symbology ADS validation studies.

FY 99 Milestones

- RPA ATD and Enhanced Lethality AWE.
- Bird Dog flight tests.
- Complete the MSCM TD.
- Conduct TACAWS platform integration. Build 8-10 missiles.
- Initiate the TACAWS ATA/ATG TD.
- Initiate LCPK TD (proposed ATD). Complete system prototyping and begin system integration.
- Initiate Distributed Target Acquisition concept development.

FY 00 Milestones

- Complete the ALERT TD.
- Initiate I2/FLIR Fusion Pilotage TD.
- Conduct TACAWS HWIL plus digital simulation. Complete helicopter and ground platform fire control and interface. Initiate soldier training for ATD and BL evaluations.

- Complete LCPK control test vehicle, proof of concept flights, and system integration. Begin LCPK test evaluation.
- Initiate Advanced Data Sensor Fusion concept development.
- Publish HMD symbology ADS.

FY 01 Milestones

- Complete Bird Dog TD and Advanced EO/IRCM TD.
- Initiate AIPSYS for NOE Operations TD.
- Complete TACAWS hardware, software and aircraft integration. Conduct 8-10 missile flights and soldier training in realistic scenarios.
- Complete LCPK TD and test evaluation. Begin aircraft integration for AWIP.
- Initiate OCSW air platform integration.

THRUST 5: SUBSYSTEMS AND LOGISTICS

Requirements

Rotary-wing vehicle subsystems encompass a broad range of S&T topics related to support, sustainment, and survivability of increasingly complex aircraft systems, and to unique problems associated with the application of high performance weapons on rotorcraft. A primary need in this area is to address affordability issues for O&S costs. Also, this area investigates the extension of the useful life of weapon systems through upgrading the armament and other mission equipment. The need to adequately address subsystem-to-subsystem and subsystem-to-system interactions and integration issues is another major focus of this technology area.

The STOs, which these technology thrusts indirectly support, overlap with those discussed in the previous discussion on MEP. The logistical support and sustainment aspect was addressed in the recently completed Logistical Rearmament-Aviation (Log Rearm-Avn) ATD and STO. The OCRs which these programs address are primarily in the Mounted Battlespace, Early Entry Lethality and Survivability, and CSS battlefield dynamics.

Goals

The goals and objectives of these S&T efforts are diverse, but are most quantifiable in the area of safety and survivability. These goals include those shown in Table X.

The overall goal of the safety and survivability program is to reduce suceptability and vulnerabiliry of Army aircraft systems while reducing structural weight, reducing development and manufacturing costs, and reducing O&S costs.

The overall goal of the logistics and maintenance program is to improve the reliability, availability and maintainability (RAM) of Army aircraft systems 10 percent by FY 2000 and 20 percent by FY 2005 through improved capability to detect impending failures, reduced maintenance labor, elimination of collateral damage. These result in significant payoffs by reducing life cycle costs and improving operational availability.

Strategy

The strategy for subsystem S&T includes the collaborative efforts of the AVRDEC, ARL, CERDEC, ERDEC, and ARDEC, as well as the other services. The safety and survivability S&T subsystems roadmap is shown in Figure 38. The logistics and maintenance S&T roadmap is shown in Figure 39.

Objective	By 2000	By 2005
Reduce radar cross-section (RCS)	25%	40%
Reduce IR signature	35%	50%
Reduce visual/electro-optical signature	35%	55%
Increase hardening to threats	20%	35%
Probability of detecting incipient mechanical component failures	90%	95%

Table X. Objectives for Subsystem and Logistics S&T Thrust.

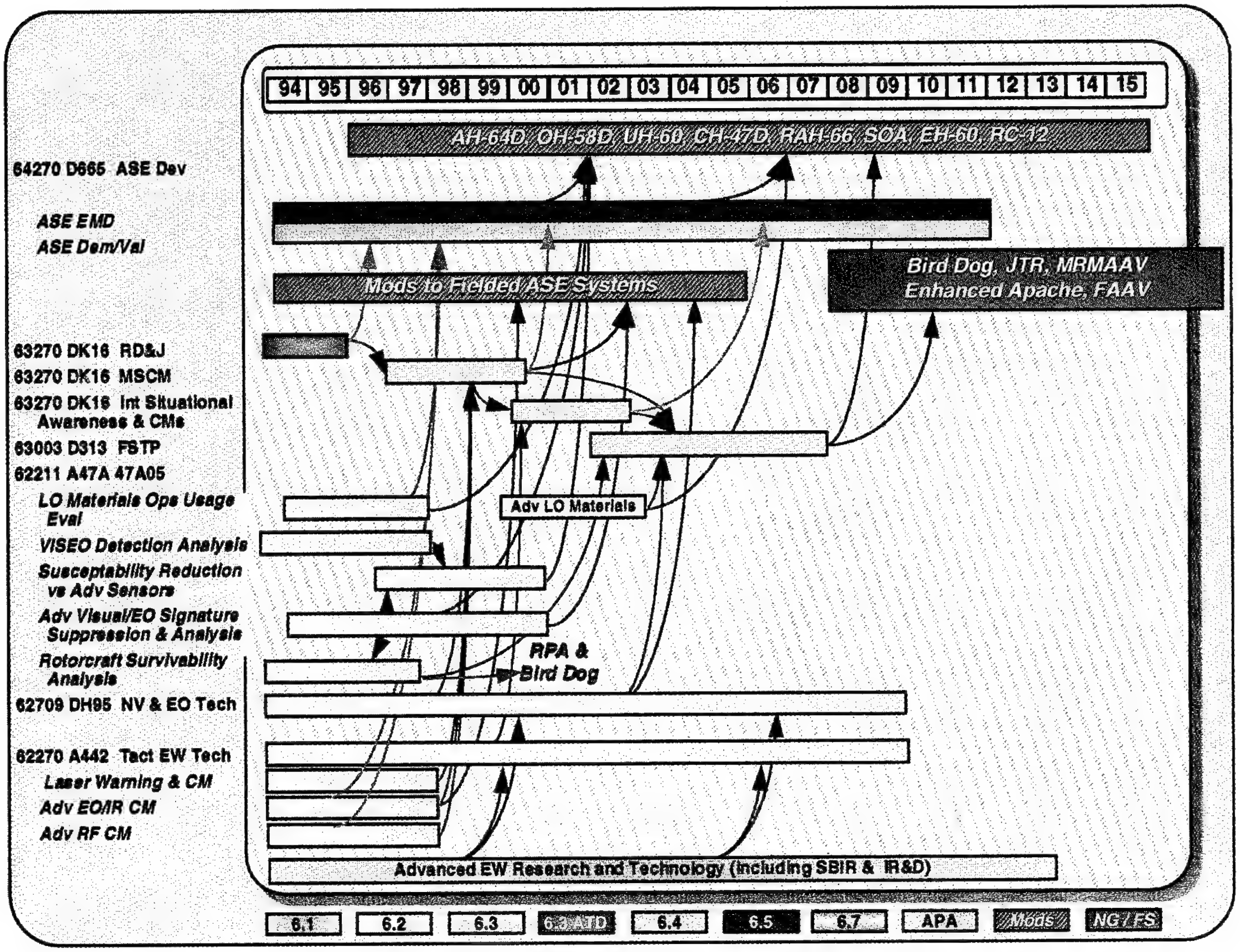


Figure 38. Safety & Survivability Subsystems S&T Roadmap.

Safety and survivability programs undertaken conduct computer modeling from signature prediction to battlefield simulations. Laboratory and flight testing are conducted using cost effective attenuating materials and design concepts that reduce IR, RCS, acoustic, visual, and electro-optical (EO) emissions from rotorcraft. Computer modeling is conducted to investigate hardening concepts to provide reduced probability of kill across the full spectrum of known threats, as well as crash impacts. The approach includes the demonstrations of components and integration of lightweight armor, directed energy weapons (DEW) and NBC hardening that balance cost, weight and effectiveness. The AVRDEC is developing a quantified database, listing the performance of advanced sensors for detecting impending component failures. Laboratory and field tests will be conducted of these advanced sensors and monitoring systems.

The logistics and maintenance S&T effort is focused on advanced mainrenance concepts (component life tracking, full on-condition maintenance (OCM), and maintenace schedules), diagnostics (expert system applications, and fuzzy logic fault detection), and prognostics (signal pattern recognition, advanced sensors, and integrated processing). The approach for achieving RAM Improvements is to improve fault detection and isolation, enhance mean time to repair (MTTR) rates, full OCM, reducing inspection time, decreasing incidence of failure and false failures, minimizing unscheduled maintenance, fewer defects, and improved airworthiness. Concepts and new technologies developed will be incorporated in CSS Battle Lab demostrations and AWEs via simulation and demonstrated in an On-Board Integrated Diagnostic System (OBIDS) TD in the FY 2002-2006 timeframe. Products from this effort will be applied to the force modernized fleet via

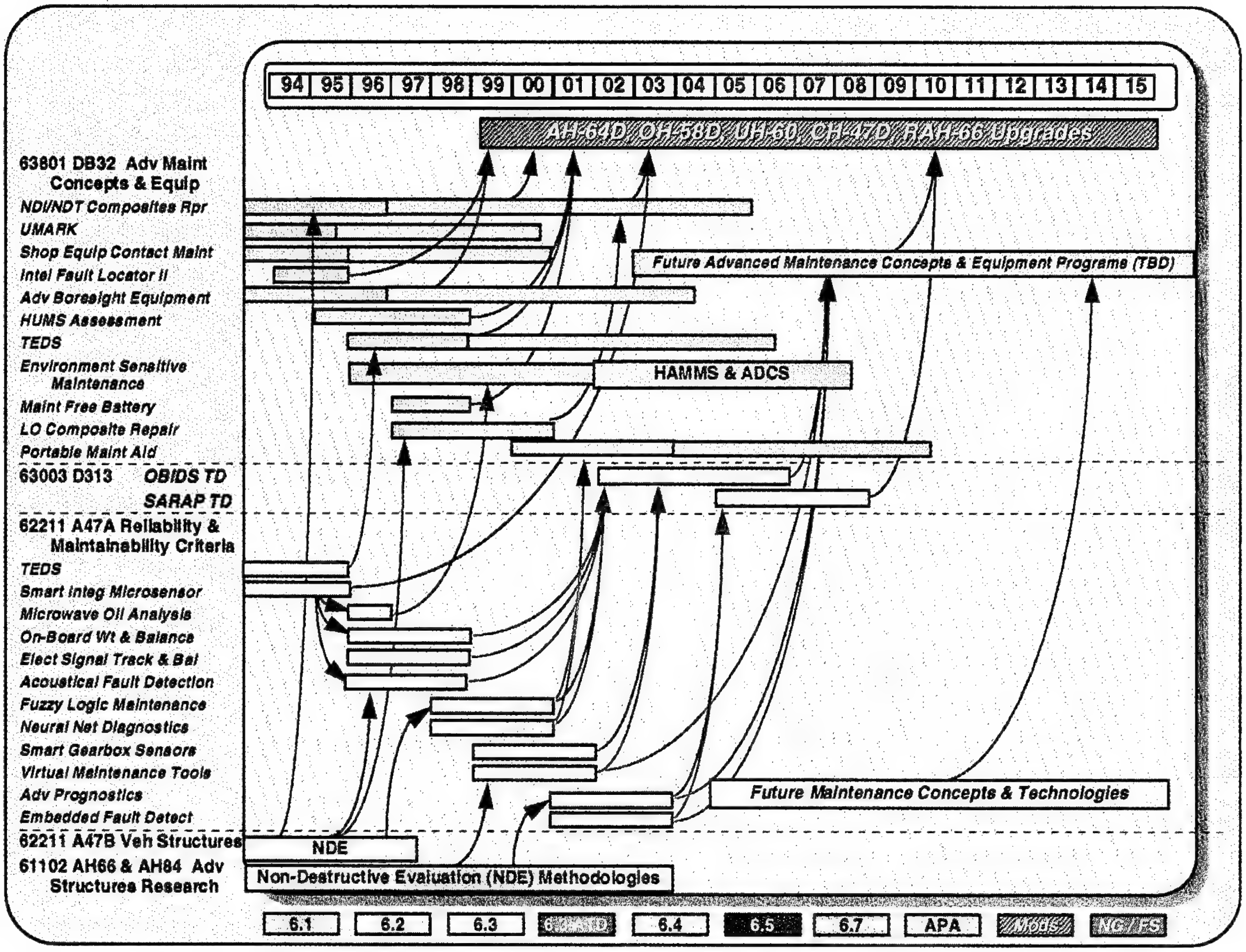


Figure 39. Logistics and Maintenance R&D / Modernization Strategy

upgrades. It also feeds technology to the 6.3 Aviation Ground Support Equipment (AGSE) project.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Completed survey of government & industry from which standardized IR/EO signature specifications and design criteria will be developed.
- Completed improved design of OH-58D LO kits.
- Designed lightweight, low thermal conductivity, durable, maintainable advanced insulation concept to reduce IR signature of engine nacelles.
- Completed laboratory test on Smart Integrated Microsensor (SIMS).
- Defined turbine engine diagnostics needs.

During FY 95, the following program milestones were achieved:

- Initiated distributed target acquisition investigation.
- Developed and flight tested rapid prototype design for AH-64 chain gun IR suppressor.
- Tested alumina-based flexible ceramic armor.
- Initiate field test of advanced comfort/crashworthy seat cushion.
- Conducted cruciform tests of crashworthy thermoplastic subfloor.
- Field test VISEO code and model.

- Selected and developed components in support of Cockpit Air Bags System (CABS).
- Defined turbine engine diagnostic opportunities.

Milestones

Major technical and program milestones in the subsystem and logistics technology thrust area in the FY 96-01 POM period include:

FY 96 Milestones:
- Complete LO materials operational usage evaluation.
- Complete advanced insulation for engine nacelles effort.
- Develop multi-spectral paint/coating pattern optimization code to obtain pattern to reduce detectability for given scenarios.
- Complete VISEO EO tracker model and validate VISEO in CASTFORM simulations.
- Complete integrated Rotorcraft Survivability Analysis Plan.
- Initiate Large Rotorcraft Crashworthiness program.
- Initiate DEW Hardening for Rotorcraft program.
- Complete CABS design for UH-60 and conduct full-scale dynamic testing.
- Initiate development of on-board weight and balance sensor.
- Initiate electrical signal track and balance signal processing analysis effort.
- Initiate acoustic fault detection monitor.
- Complete microwave oil analysis in-flight oil morphology sensor.

FY 97 Milestones:
- Initiate Helicopter Susceptability Reduction vs. Advanced Sensors program.
- Initiate investigation of new materials and applications for rotorcraft canopies to minimize cues from glint.
- Develop, fabricate and laboratory test prototype on-board weight and balance sensor.
- Develop, fabricate and laboratory test prototype signal processing unit.

FY 98 Milestones:
- Demonstration of integrated high-speed bus diagnostics.
- Complete integration and flight test of on-board weight and balance sensor.
- Complete integration and flight test of signal processing unit.
- Fabricate and rig test prototype acoustic fault detection monitor.
- Initiate Fuzzy Logic for Maintenance program.
- Initiate Neural Network Diagnostics program for aircraft maintenance.

FY 99 Milestones:
- Complete Susceptability Reduction vs. Advanced Sensors program, complete survivability analysis.
- Complete canopy glint suppression technology investigation.
- Initiate Advanced LO Materials program.
- Develop Fuzzy Logic Maintenance software prototype.
- Develop software for prototype Neural Network Diagnostics.
- Initiate Virtual Maintenance Tools technology investigation.

FY 00 Milestones:
- Conduct Fuzzy Logic for Maintenance demonstration.
- Conduct Neural Network Diagnostics demonstration.
- Design and fabricate prototype Virtual Maintenance hardware and software.

FY 01 Milestones:
- Test and simulation of Virtual Maintenance Tools.

THRUST 6: MANUFACTURING S&T

Requirements

In order to shorten the acquisition life-cycle, reduce acquisition costs, introduce new technologies to the production process, and develop new/modified production process for high technology systems, the Army has an established integrated program that supports systems Army-wide. The Manufacturing Science and Technology (MS&T) program provides support for development and production of Army aviation systems throughout the product life cycle. MS&T seeks to improve the production of rotary-wing aircraft by developing and demonstrating new or improved manufacturing processes and techniques. Efforts are production oriented and are directed at advanced technologies that reduce the system timeline from product concept to field use. The MS&T program also includes the development of repair and remanufacturing processes to support increased needs for extending material life.

Goals

The goal and objectives of the MS&T program is to reduce life-cycle cost and riskd associated with acquisition and support of Army aviation materiel. These will be accomplished through various tasks as shown in Figure .

Strategy

The technology investment strategy for MS&T (Figure 40) concentrates on technology opportunities that will significantly improve the capabilities of the industrial base to produce high

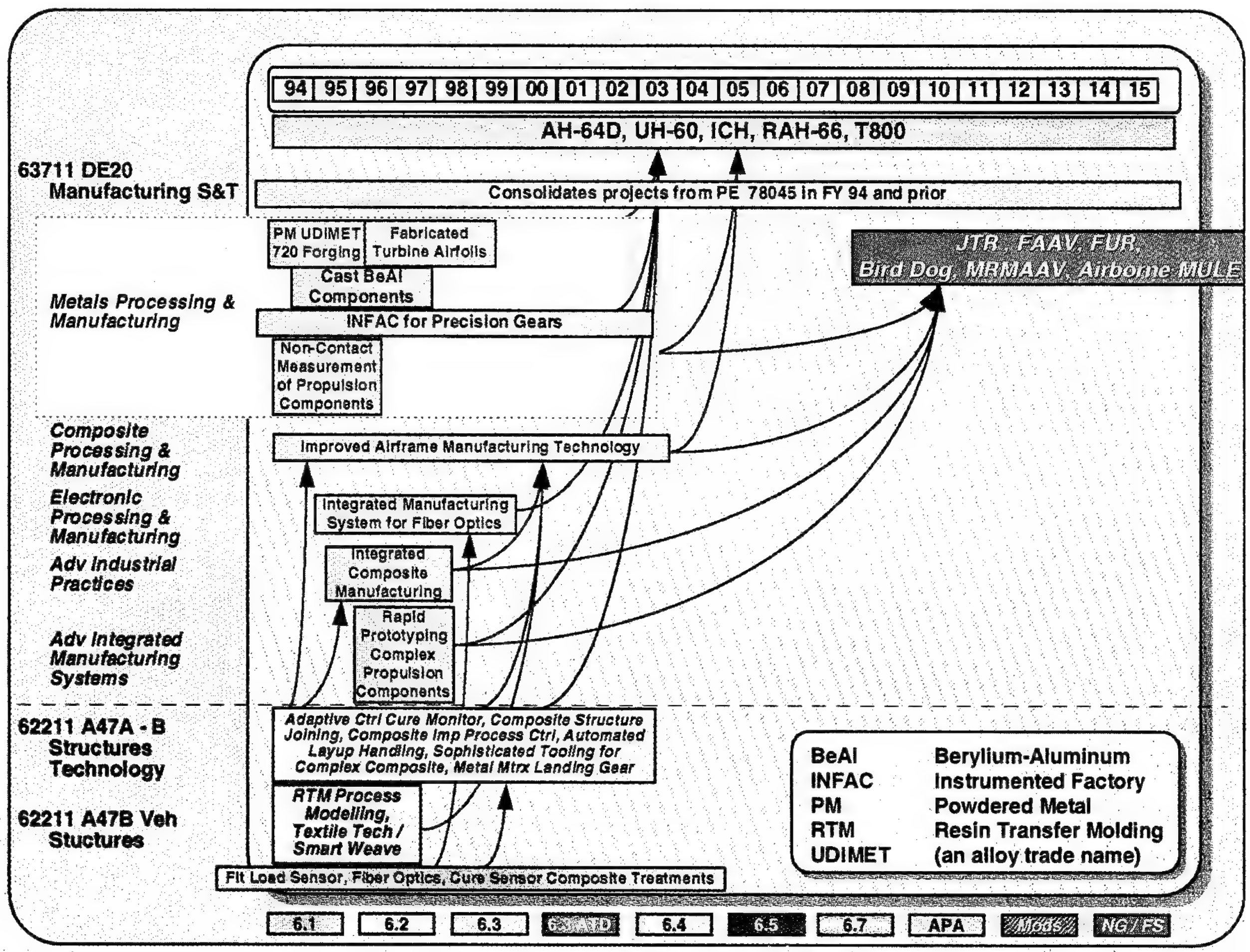


Figure 40. Aviation Manufacturing S&T Strategy.

quality, affordable materiel. The program will facilitate manufacturing technology transfer from the R&D community to the industrial base and will further the development of manufacturing processes that are environmentally friendly.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Developed Udimet 720 powder using gas atomization process.
- Developed forging billets using HIP extrusion process.
- Developed cluster forging process and produced T800 turbine disks.
- Developed hardware/software specifications for non-contact measurement system.
- Developed high level inspection system design.
- Developed Berylium-Aluminum (BeAl) casting process specifications.
- Designed tooling/molds for casting BeAl components.
- Conducted BeAl casting trials.
- Developed modeling concept for prediction and control of heat treat distortion in gears.
- Developed ring rolling process for producing turbine disks spacers.
- Conducted preliminary studies for high energy hardening of precision gears.

Milestones

Major technical and program milestones in the MS&T aviation program in the FY 96-01 POM period include:

FY 96 Milestones:
- Conduct modeling/simulation of BeAl cast component.
- Demonstrate non-contact inspection system in production environment.
- Demonstrate gear heat treat distortion prediction model.
- Develop high energy selective hardening process for gears.
- Develop fiber optic segment system detailed specification.
- Demonstrate co-cure of thick section, complex composite component.

FY 97 Milestones:
- Develop process for casting recycled BeAl material.
- Conduct mechanical evaluation of fabricated turbine blades.
- Demonstrate thin wall RTM for primary structures.
- Develop fiber optic harness system detailed specification.

FY 98 Milestones:
- Develop injection molding of structural and non-structural components.
- Conduct pilot production demonstration of fabricated turbine blades.
- Develop repair process for fabricated blades.

FY 99 Milestones:
- Complete integrated manufacturing for fiber optics project.
- Continue Instrumented Factory (INFAC) for precision gears.
- Continue improved airframe manufacturing technology project for composite structural and non-structural components.

FY 00-01 Milestones:
- Continue Instrumented Factory (INFAC) for precision gears.
- Continue improved airframe manufacturing technology project for composite structural and non-structural components.

AVIATION SYSTEM / SUBSYSTEM R&D - DEMONSTRATION/ VALIDATION, EMD, TEST & EVALUATION, AND PRODUCT IMPROVEMENTS

AIRCRAFT SURVIVABILITY EQUIPMENT (ASE)

Requirements

The ASE project provides for the development and integration of hardware, software, and procedures to provide Army aircraft and aircrews with the means necessary to warn of, protect against, and counter threat weapon systems. Equipment developed will increase combat effectiveness and potential for mission accomplishment by reducing or eliminating the ability of threat air defense systems to detect, engage, hit, damage, or destroy Army aircraft. Current ASE development programs respond to two complimentary User Operational Requirements Documents (ORD) addressing Infrared (IR), Radio Frequency (RF), and optical/Electro-Optical (OE) directed air defense threats, i.e., the ORD for Suite of Integrated IR Countermeasures (SIIRCM) and the ORD for Suite of Integrated RF Countermeasures (SIRFC).

The SIIRCM ORD identifies a need to provide Army aircraft with a lightweight, multifunctional system to protect the aircraft and aircrews from threat IR and EO weapon systems. The system must be an integrated suite that provides 360° warning and protection against IR and EO-guided threat missiles, require less than 3kW electrical power to operate, and weigh no more than 145 pounds. The SIIRCM is composed of three subelements: (1) the Advanced Threat IR Countermeasures (ATIRCM), which includes the Advanced Threat IR Jammer (ATIRJ), the Common Missile Warning System (CMWS), and the Advanced Dispenser System (ADS); (2) the Advanced IR Countermeasure Munition (AIRCMM); and (3) passive IR features.

The SIRFC ORD addresses the need to provide Army rotary and fixed wing aircraft with a compact, lightweight pulse, pulse doppler, and continuous wave RF electronic countermeasure system. The system must provide 360 degrees of coverage, have a low probability of exploitation, integrate with common displays, control panels, sensors and processors, and be easily reprogrammable. The SIRFC consists of the following subelements: (1) the Advanced Threat Radar Jammer (ATRJ), which includes an Advanced Threat Radar Warning Receiver (ATRWR) function and an optional Escort/Standoff Jammer (ESJ) capability; and (2) Advanced Active RF Expendables (AARFE).

The Army is designated as lead service for development of ASE for rotary wing aircraft. In addition, the Army's missile warning program has been selected as the Tri-service CMWS. Candidate platforms for the ATIRCM and SIRFC include the AH-64D, RAH-66, AH-1W, OH-58D, CV-22, MH-47E, MH-60K, RC-12K, EH-60A/L, CH-47D, and UH-60A/L. ASE programs support OCRs in the Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, and EELS battlefield dynamics which require that the host platform be protected from threat weapon systems, ensuring its survivability on the digital battlefield and performance of the mission assigned.

Goals

> *"The goal of ASE integration is to maximize the synergistic effect of aviator, ASE, MEP and aircraft platform resulting in maximum mission effectiveness."*

The main vision of the ASE program is to provide aircraft with a fully integrated, modular, adaptable, and affordable suite to protect against hostile ari defense weapon systems. The objective is to replace the current individual and federated ASE items with a multi-functional, lightweight, reprogrammable suite of ASE that capitalizes on leading edge technologies in

electronics, microprocessors, and sensor and data fusion.

In particular, the ATIRCM will replace the ALQ-144 IR Jammer, ALQ-156 Missile Detector System, and the M-130 flare/chaff dispenser. Likewise, the SIRFC will replace the current APR-39 family of radar warning receivers, and the ALQ-136 and ALQ-162 family of pulse and continuous wave RF jammers. Together, the SIIRCM and SIRFC will provide a fully coordinated countermeasure response capability.

Strategy

The ASE modernization strategy/roadmap is shown in Figure 41. Projects currently in development include new or upgraded system to counter monopulse, milimeter wave, frequency agile, pulse doppler, and continuous wave radars; passive IR missile seekers; and laser directed weapon systems. The effort also includes joint service applications that are coordinated through the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS), as well as NATO applications coordinated through OSD. The long range strategy for the development and integration of ASE is to achieve the next level of integration, namely the synergistic integration of ASE with situational awareness, navigation systems, C2, and weapon systems. The integration will optimize the the ASE capability by using common interfaces, processors, and sharing of sensor data (Figure 42).

The integration methodology is a five phased, building block approach with the objective of ensuring the availability of the aircraft "A-kits" prior to the hardware "B-kits". An Advanced

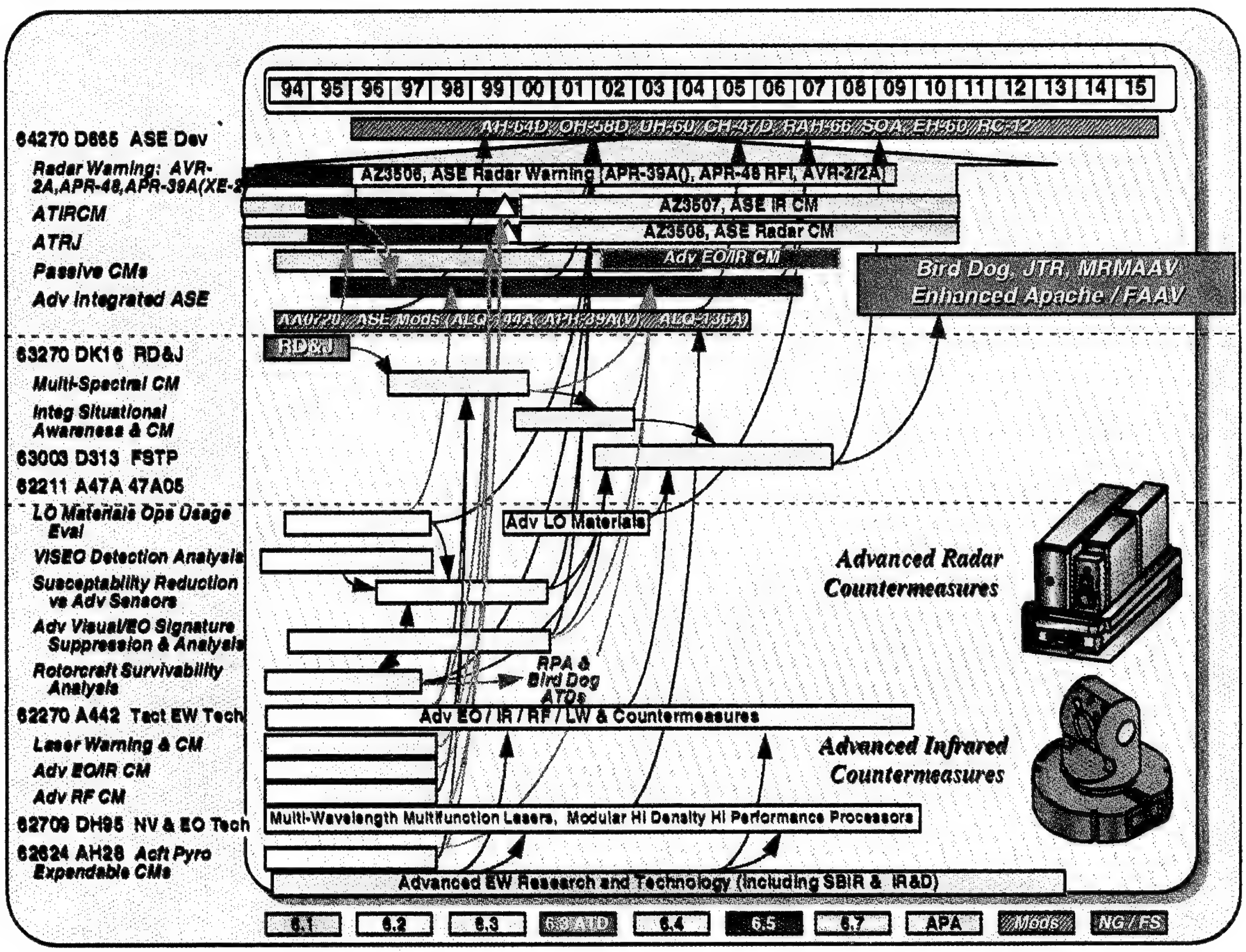


Figure 41. ASE Modernization Strategy/Roadmap.

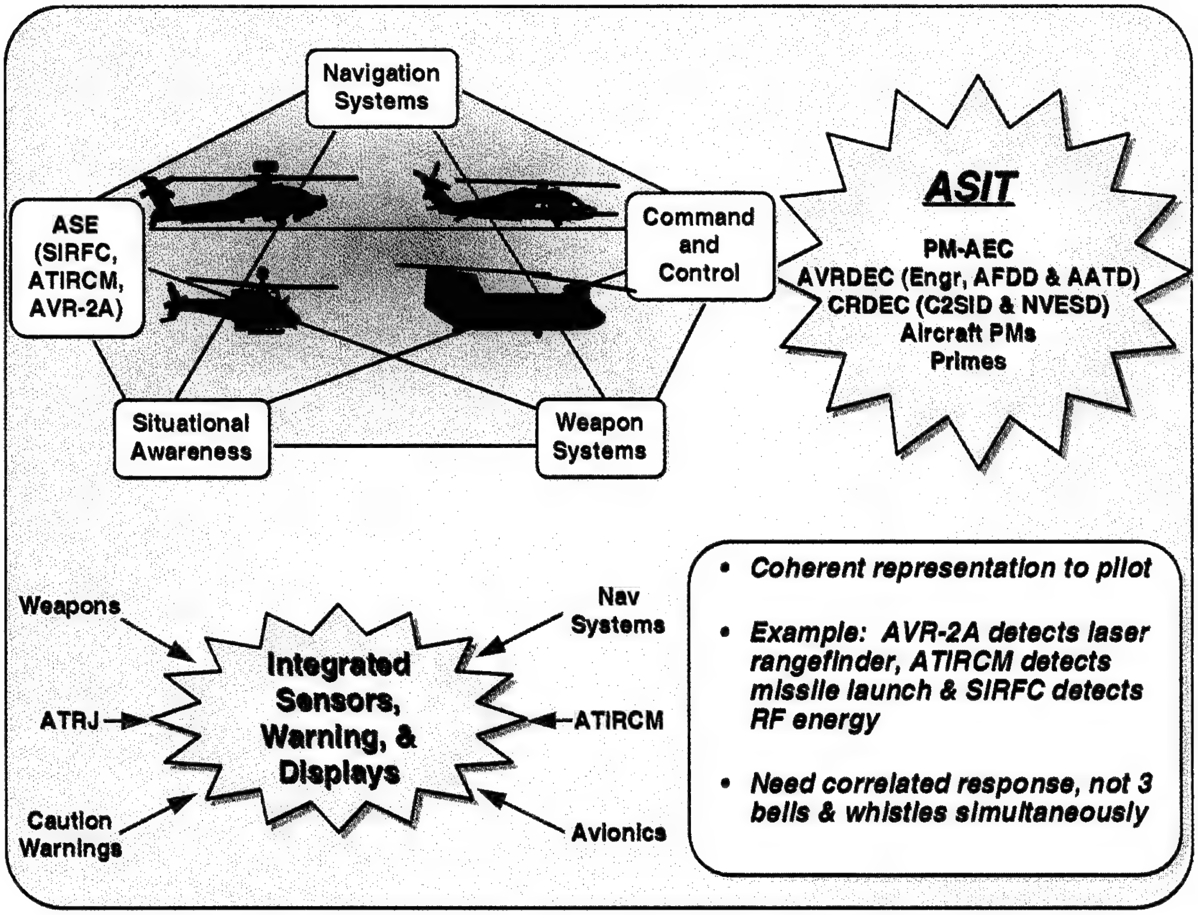


Figure 42. ASE Integration and ASIT.

Systems Integration Team was established in FY95 that brings together experts from the AVRDEC, CRDEC's Night Vision and Electronic Sensors Division, Aviation Electronic Combat (AEC) Project Management Office (PMO), the aircraft PMOs, software engineers (AVRDEC & CRDEC), the aircraft prime contractors, and the "black box" prime contractors. Phase 1, Engineering Analysis, examines aircraft configuration options and integration opportunities. Phase 2, Simulation, verifies systems interface in a laboratory environment. Phase 3, Prototype Development, modifies one aircraft with changes needed for testing to validate Phases 1 and 2 and identify the best options. Phase 4, Testing, is thorough performance testing leading to approval of the aircraft Engineering Change Proposal (ECP). Phase 5, Fielding, is completion of A-kit development and installation at the same time or prior to B-kit production.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Completed SIRFC Dem/Val, DT & OT I and Milestone II.
- SIRFC EMD Contract awarded.
- Continued Dem/Val of IR Expendables.
- Completed EMD of AN/APR-48A RFI.
- Continued EMD of AN/APR-39A(XE-2) Radar Signal Detecting Set (for SEMA).
- Continued Dem/Val of ATIRCM.
- Completed Dem/Val of IR Expendables.
- Continued development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.
- Completed demo and transitioned 2-color IR flares to PM-AEC (from AH28 to D665).

During FY 95, the following program milestones are being achieved:

- SIRFC EMD preliminary design review.
- Completed EMD of AN/APR-39A(XE-2).
- Awarded ATIRCM EMD contract.
- Initiated EMD of IR Expendables.
- Initiated ATIRCM & ATRJ integration.
- Continued development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.
- Initiated ASE integration efforts.

Milestones

FY 96 Milestones
- Conduct SIRFC critical design review.
- Conduct ATIRCM preliminary and critical design reviews.
- Continue EMD of IR Expendables.
- Continue development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.
- Continue ASE integration efforts.

FY 97 Milestones
- Deliver SIRFC for prototypes DT/OT II.
- Deliver ATIRCM DT/OT II prototypes.
- Continue EMD of IR Expendables.
- Continue development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.
- Complete ASE integration efforts.

FY 98 Milestones
- Complete SIRFC DT/OT II.
- Continue ATIRCM DT/OT II.
- Complete EMD of IR Expendables.
- Continue development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.

FY 99 Milestones
- Conduct SIRFC Milestone III review and award production contract.
- Conduct ATIRCM Milestone III review and award production contract.
- Continue development of Passive IR features for reduction of all aircraft signatures in all IR bands relative to heat-seeking missiles.

FY 00 Milestones
- Initiate ATIRCM & SIRFC integration for MH-47E.
- Complete EMD of IR Expendables.

FY 01 Milestones:
- Complete ATIRCM aircraft integration.
- Initial production deliveries of SIRFC and ATIRCM.

AVIONICS

Requirements

The Aircraft Avionics project provides for the development of electronic systems required to horizontally and vertically integrate Army aircraft on the digital battlefield. These efforts are in direct response to approved requirements documents and the Army's digitization of the battlefield initiatives. Digitization is the application of information technologies to acquire, exchange, and employ timely information throughout the battlespace, tailored to the needs of each decision maker, shooter, and supporter. The digitization of the aviation avionics program involves voice, data, and imagery projects. The critical requirements are joint and combined arms interoperability and digital interconnectivity, enhanced aircrew situational awareness, improved navigational accuracy, improved night/adverse weather performance, nonline-of-sight (NLOS) and NOE flight communications, and mission rehearsal and preloading of mission parameters.

Goal

The main thrust of the aviation avionics project is toward systems which enhance situational awareness, command and control, and operational tempo. The objective is to enable

Army aviation assets to be digitally compatible and interoperable on the electronic battlefield. Within limited funding resources, the goal is to develop, acquire avionics systems to be fielded on the optimum number of aircraft via system upgrades or through technology insertion on active production lines.

Strategy

Key to the avionics modernization strategy (Figure 43) is the development of an Aviation Systems Architecture (ASA). The ASA will be a subset of a Department of the Army weapons systems architecture and will capture Army common, aviation common and platform mission specific requirements, standards and physical implementations. The ASA is the first of four weapons systems domains to be documented. The ASA will result in a documented baseline which will provide improved holistic architecture, data exchange, commonality and reuse, integration, and infrastructure. Additional benefits include improved manageability and accountability by providing improved profiles for performance, schedule, costs, and training, and avoids duplication between systems and services. Due to limited funding, near term avionics hardware development projects are focused on six core enabling programs (Figure 44) with the intent to upgrade Force Package I (contingency and forward deployed forces) aircraft. Maximum use will be made of non-developmental items (NDI) and off-the-shelf components.

The Global Positioning System (GPS) RDT&E effort addresses Army aircraft space, weight and power limitations by embedding a GPS circuit card into existing onboard avionics systems. The Embedded GPS Inertial Navigation Unit (INU) (EGI) is a joint program with the Air Force in the lead. The EGI is to be applied to attack and reconnaissance aircraft. Utility and cargo aircraft are to be equipped with Doppler embedded GPS Navigation System (DGNS). Both GPS solutions incorporate military P(Y) code capabilities, are integrated into the weapons systems avionics, and have anti-jam, anti-spoof features.

The AN/ARC-220 HF radio will provide a long range, NOE, NLOS voice communications capability which is reliable, secure, and easy to operate, with automatic link establishment and electronic counter-countermeasures. It is compatible with the MIL-STD-1553B data bus and will be form and fit interchangeable with the AN/ARC-199 HF radio.

The Army Airborne Command and Control System (A2C2S) functions as a highly mobile airborne command post. Mounted in a UH-60, it provides tactical voice, data, and imagery digitized battlefield communications (secure and non-secure modes) for corps, division, and maneuver brigade commanders. The system provides access to critical situational awareness and off-board national asset intelligence information via satellite communications; digital battlefield communications links with army team members, joint service and combined force elements; and intercommunications facilities for up to six operators. The UH-60 A2C2S will enable the commander and essential staff to remain highly mobile with the capability to interject critical C2 across the designated battle area without sacrificing access to information products or jeopardizing continuity of operations due to command post relocation.

The Aviation Mission Planning System (AMPS) is a planning and battle synchronization tool that will automate aviation mission planning tasks. The system provides for generation of mission data in hard copy or electronic format. It includes tactical C2, mission planning, mission management, and maintenance management. It provides an interface with the Maneuver Control System (MCS) and associated networks to provide the aviation commander with continuous situational awareness. Development of the AMPS is continuing using the core capabilities of the Air Force Mission Support system. An interim AMPS, using Common Hardware/ Software (CHS) I hardware with a data transfer device, has been fielded with the Kiowa Warrior. Production systems using CHS II hardware will be available to support the fielding of Longbow Apache. The AMPS is also

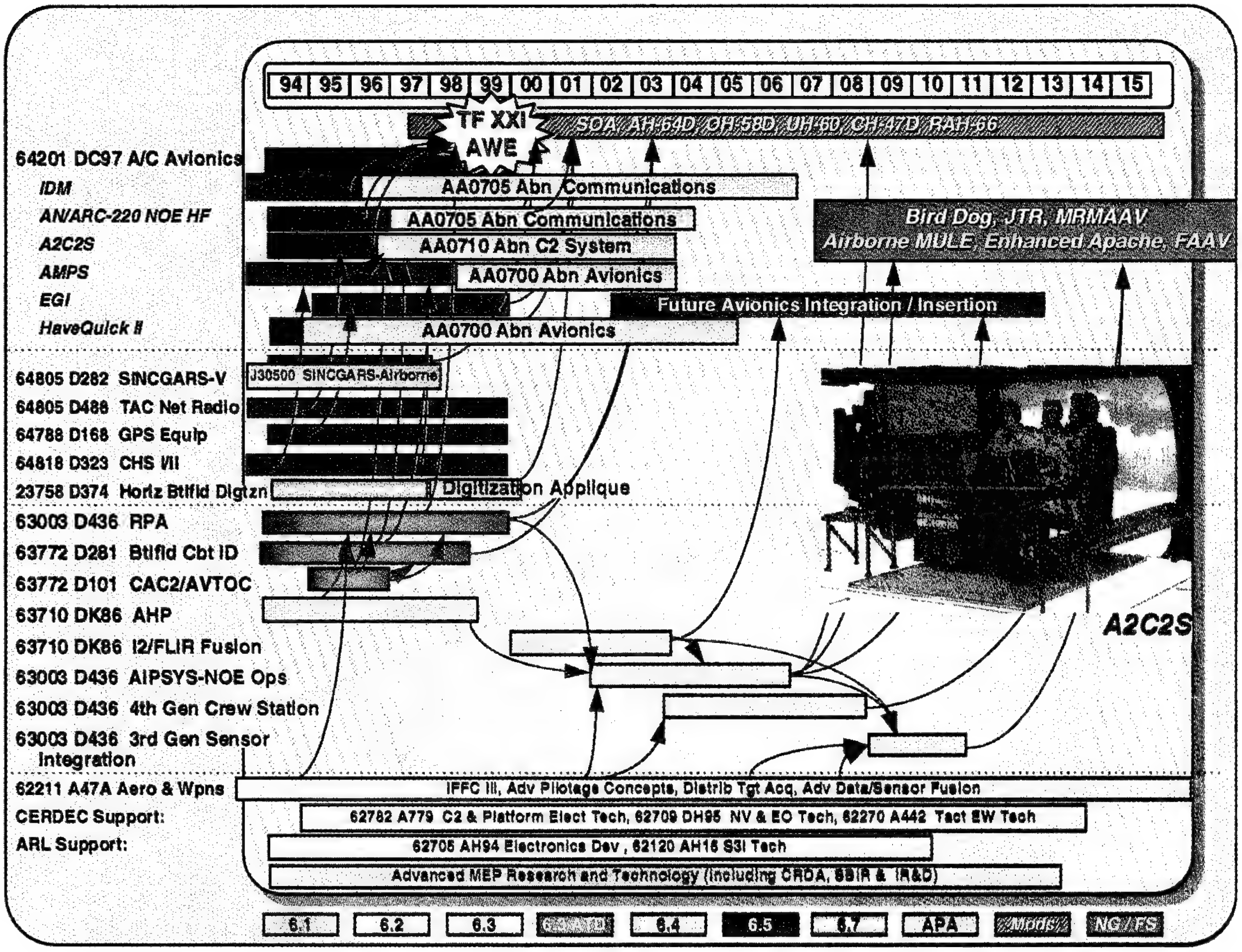


Figure 43. Aircraft Avionics R&D Roadmap.

included as a subsystem of the A2C2S and AVTOC.

The Air Force has upgraded the AN/ARC-164 Have Quick (ECCM capable) family of radios to HQ II, which is the standard for joint service UHF-AM communications. The upgrade provides for ANVIS compatibility and a fill-port for electronic data loading, and extended period secure capability. Efforts are on-going to standardize all Army aircraft with HQ II configurations and ground timing systems which are required for synchronization of Army HQ II nets and improved logistic supportability.

The Improved Data Modem (IDM) is at the heart of aviation's digitization initiative. It is a "receive and transmit" terminal that performs message processing and distribution functions and has direct connectivity with up to four platform transceivers for simultaneous communications. The IDM is the joint service standard for the exchange of digital information across all aviation combat net radios. Utilizing common Army and joint formatted messages that are normally filled from platform avionics components, information such as situation and spot reports, or targeting information can be quickly and concisely formatted and passed horizontally and vertically. The IDM recognizes multiple joint protocols used by the Army, Air Force and Marine Corps, and is being upgraded to include MIL-STD 188-220() and the variable message format under development for the Task Force 21 (TF XXI) initiative.

Additional projects include the Aviation Tactical Operations Center (AVTOC) which is

part of the command and control mission area managed by PEO Command, Contol, and Communications Systems (C3S). The AVTOC is based on the Standard Integrated Command Post (SICPS), and complements the Command and Control Vehicle (C2V). It will interface with MCS; have long range NOE communication; provide communications interface to Combat Net Radios (CNR), Area Command User System (ACUS), Army Digitized Data System (ADDS), division and /or Corps command nets; and provide the capability for automated aviation mission planning. Aviation Electronic Combat PMO and AVRDEC personnel will work with the PEO C3S and CECOM to ensure unique aviation requirements are satisfied in this important digitized command facility.

Task Force 21 Appliqué functionality will enhance situational awareness, command and control, operational tempo, and mission planning. This functionality will be incorporated into bussed scout and attack aircraft through the IDM and by installation of Appliqué systems on non-bussed cargo and utility aircraft. Software updates to accommodate changes necessary for interface to the TF XXI Appliqué battle command system will be made to the IDM and aircraft processors as required.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Initiated EMD of the AN/ARC-220 NOE communications HF radio.
- Initiated A2C2S subtasks for:
  - *Enhanced Communications Interface Terminal (ECIT)/workstation prototype and demonstration.*
  - *C3 Risk Reduction Study.*
  - *Antenna Study and prototypes.*

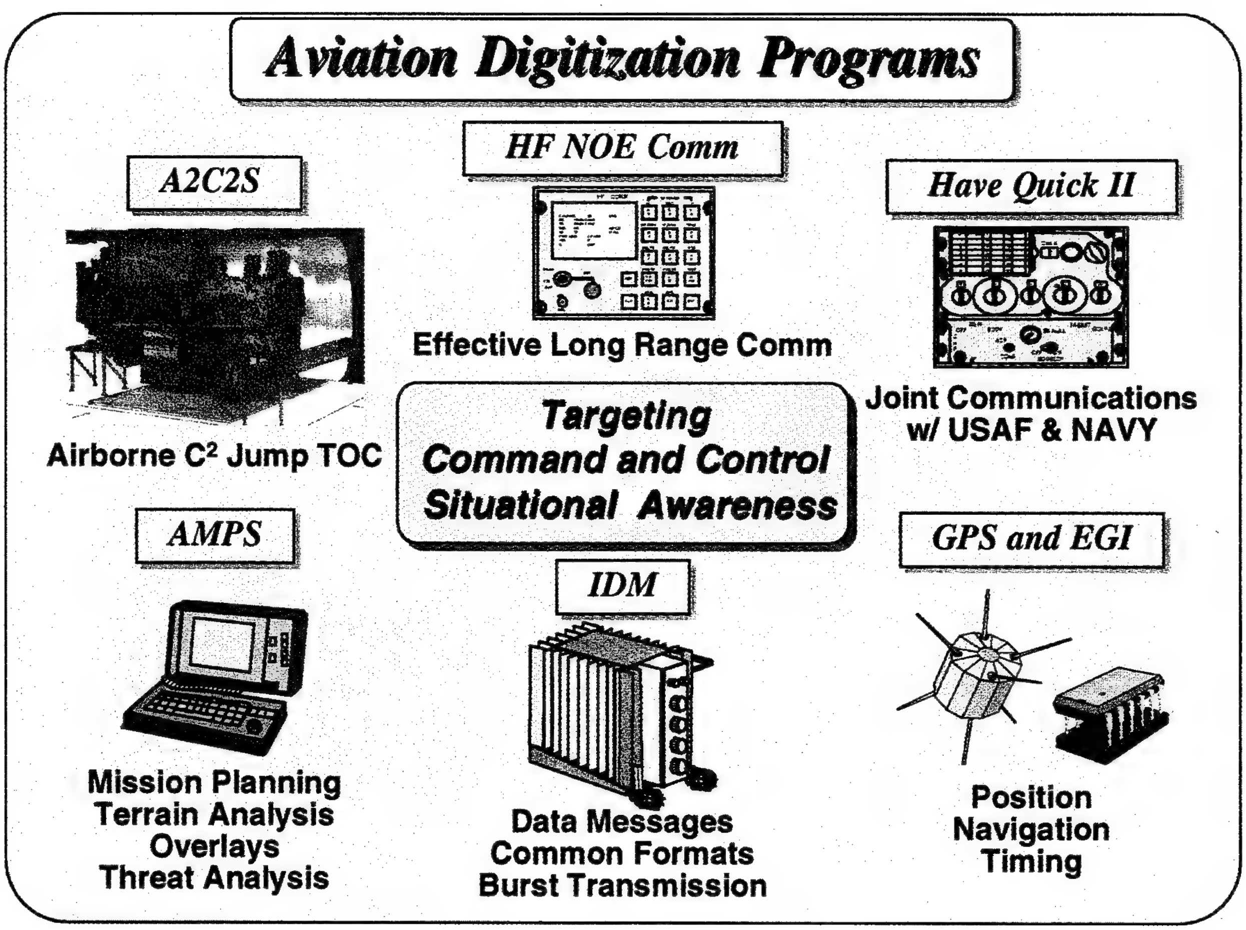


Figure 44. Core Aviation Digitization Programs.

- *Multi-Application Tactical Terminal and Commander's Situational Awareness Workstation*
- *Aircraft Systems Integration Demonstration*

During FY 95, the following program milestones were achieved:

- Preproduction qualification of AN/ARC-220.
- Conducted non-recurring engineering for EGI.
- Initiated AH-64D EGI integration.
- Longbow Apache (AH-64D) completed DT&E with integrated IDM.

Milestones:

FY 96 Milestones:
- Complete AN/ARC-220 EMD effort.
- Contract award for AN/ARC-220 A-kit and testing.
- Deliver IDM software for TF XXI.
- Complete IDM integration on TF XXI Kiowa Warrior (OH-58D) aircraft.
- Deliver IDM software for AH-64D & OH-58D production/retrofit aircraft.
- Upgrade AMPS software for full integration capability with RAH-66 architecture.
- Initiate AMPS life cycle software non-recurring engineering.
- Develop Enhanced ECIT and A2C2S prototypes (6).
- Design and develop A2C2S Workstation Consoles and software.
- Phase II development of A2C2S Antenna System.
- Test and demonstration of A2C2S EMD hardware.
- Tri-Service IDM Program Management Transfer from F-16 SPO (Wright Patterson AFB, OH) to Electronic Systems Center (ESC, Hanscom AFB, MA).

FY 97 Milestones:
- Complete AMPS software integration upgrade.
- Complete AMPS life cycle software non-recurring engineering.
- Complete IDM integration on Special Operations Aircraft.

FY 98 Milestones:
- Complete AMPS EMD.
- Complete AH-64D EGI integration.
- Complete IDM integration on UH-60Q Medevac helicopter.

FY 99 Milestones:
- Complete A2C2S EMD.
- Conduct TF XXI digitization AWE demonstration of A2C2S, AMPS, and AN/ARC-220.
- Complete integration of MIL STD 188-220/VMF IDM software on AH-64D and OH-58D production aircraft

FY 00 Milestones:
- Project unfunded.

FY 01 Milestones:
- Complete IDM procurements for all Army platforms except AH-64D.

AVIATION LIFE SUPPORT EQUIPMENT (ALSE)

Requirements

The ALSE program encompasses items of equipment needed to protect, sustain, and enhance the performance of Army aircrews and passengers, on the ground and during flight. ALSE enhances mission performance and aircrew survivability during operational missions, in crash situations, and in post crash/prior to rescue conditions. The need exists for ensuring that aircrews are adequately equipped to maximize survival. This includes the flight uniform and helmets, survival kits, NBC detection, warning, contamination avoidance and protection equipment, flotation devices, emergency egress concepts, crew restraint and crash protection systems, environmental control and oxygen systems, and laser eye protection. The ALSE program addresses OCRs across the spectrum of

battlefield dynamics. The requirements for the survivability and sustainability of the individual soldier are embedded in multiple OCRs, but especially in the Mounted and Dismounted Battlespace dynamics and the Early Entry, Lethality and Survivability dynamic.

Goals

The primary goal of the ALSE program is to develop and field items of equipment which will maximize the chances of survival of the aircrews in a hostile battlefield environment and aircraft mishaps and accidents, without degrading mission performance, and to enhance mission performance of the individual by reducing physical and mental stresses.

Strategy

The ALSE projects demonstrate, validate, and fully develop and integrate safety, survivability, and soldier sustainment technologies transitioning from multiple sources: the RDECs (AVRDEC, BRDEC, NRDEC), ARL, the other services, as well as from industry/commercial via the NDI process. The emphasis is on the joint service Air Warrior program. A derivative of Land Warrior, Air Warrior will develop unique aircrew requirements to integrate multiple ALSE technologies into a system for the aircrew, to define aircraft integration to assure its overall functional interface, enhance crew performance, and reduce unit and life cycle costs associated with the current generation of individual, non-integrated items of ALSE. Air Warrior consolidates previous planned efforts for an integrated aircrew uniform, common integrated aviator's helmet, improved laser eye protection, microclimate conditioning system, NBC protective overgarment, and personal communications and computing devices. Air Warrior will provide the aircrew with a systems approach to CB protection, noise protection, microclimate conditioning, crash and post-crash survivability, concealment and environmental protection, night vision capability, heads-up displays, nuclear flash protection, directed energy eye protection, and flame and heat protection.

The other major effort is the Joint Cockpit Air Bag System (JCABS). A derivative of the CABS effort nearing completion of development for application to the AH-64, JCABS will provide a common crew restraint and crash protection system for both rotary and fixed wing aircraft. The JCABS effort will evaluate a variety of supplemental restraint system approaches to improve crew and passenger crash survivability. The overall ALSE strategy/roadmap is shown in Figure 45.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Continued fabrication and evaluation of advanced laser eye protection visor.
- Completed EMD, evaluation and testing of Integrated Head and Body Restraint System (IBAHRS).
- Developed Air Warrior program definitiion and concept plans.
- Initiated development of JCABS. Continued advanced development of Agile Laser Eye Protection program.
- Performed product improvement and follow-on testing of Aircrew Integrated Helmet System (AIHS) for M43 compatibility.
- Tested and evaluated Aircrew Microclimatic Conditioning System (AMCS) prototypes.

During FY 95, the following program milestones are being achieved:

- Completed Milestone 0 for Air Warrior.
- Conduct Air Warrior advanced development and technology trade-offs (via modeling and simulation).
- Continued fabrication and evaluation of Army version of Agile Laser Eye Protection program.
- Completed Milestone III for IBAHRS.
- Initiated EMD for AH-64 CABS.
- Continued development of JCABS.
- Conducted AIHS P3I efforts to incorporate nuclear flash protection, active noise reduction, and inertial head/neck restraint.

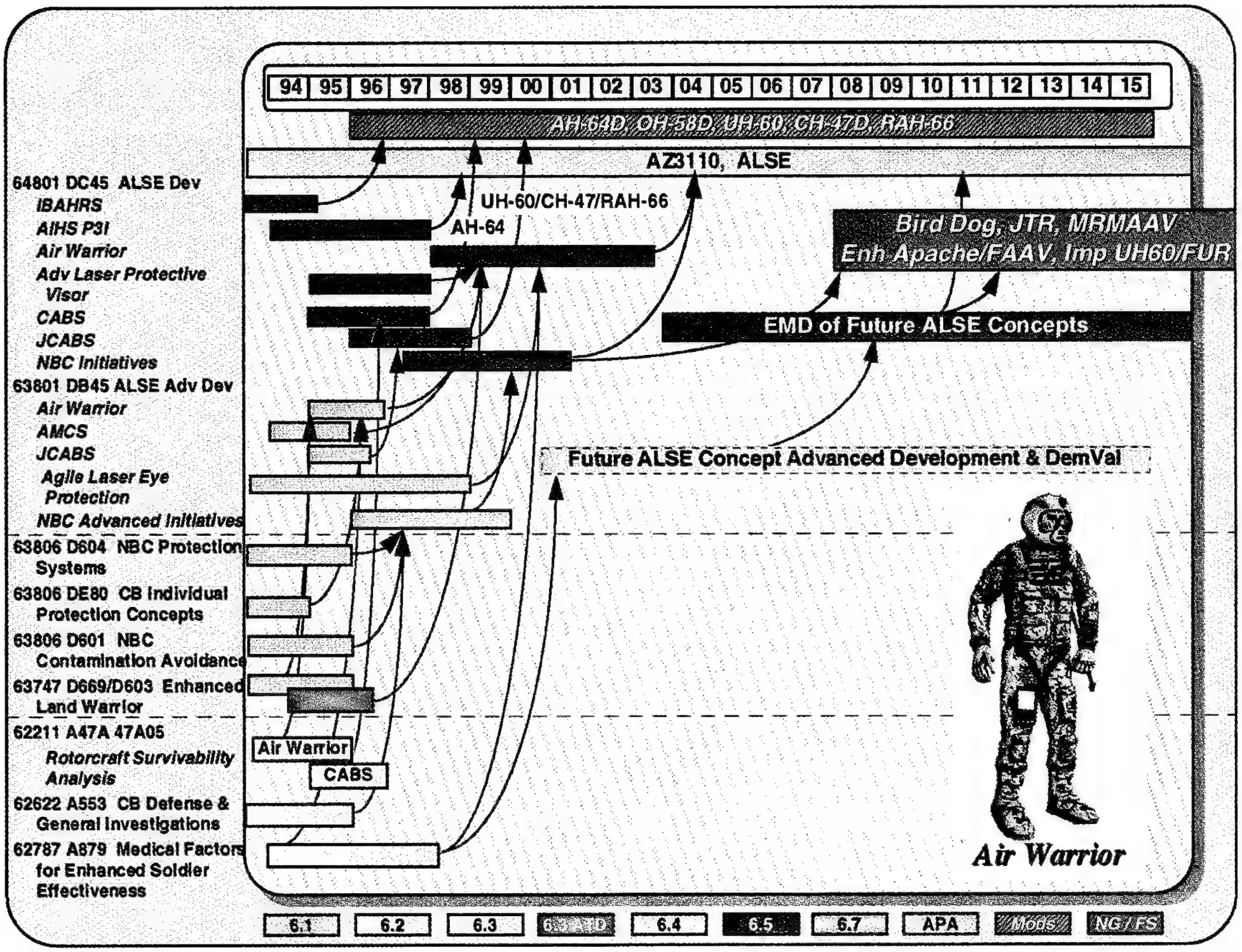


Figure 45. ALSE R&D Roadmap.

- Completed AMCS test and evaluation.
- Initiated EMD for joint Advanced Laser Protective Visor.

Milestones:

FY 96 Milestones:
- Initiate Dem/Val phase of Air Warrior and evaluate prototype design alternatives.
- JCABS Dem/Val Miestone II.
- Initiate JCABS EMD program.
- Continue fabrication and evaluation of Army version of Agile Laser Eye Protection program.
- Initiate NBC Advanced Initiatives Development for air vehicle and crew.
- Continue EMD for AH-64 CABS, AIHS P3I, and Advanced Laser Protective Visor.

FY 97 Milestones:
- Complete Air Warrior Dem/Val and evaluate prototype designs (Milestone I/II).
- Conduct Air Warrior Early User Test and Evaluation.
- Continue fabrication and evaluation of Army version of Agile Laser Eye Protection program.
- Continue NBC Advanced Initiatives Dem/Val.
- Complete EMD qualification testing and evaluation of AH-64 CABS.
- Complete EMD for Advanced Laser Protective Visor.
- Complete AIHS P3I and operational testing.
- Continue JCABS EMD.
- Initiate EMD program for NBC Initiatives.

FY 98 Milestones:
- Complete fabrication and evaluation of Army version of Agile Laser Eye Protection program.
- Continue NBC Advanced Initiatives Dem/Val and EMD.
- Initiate Air Warrior EMD program.
- Complete JCABS EMD.

FY 99 Milestones:
- Complete NBC Advanced Initiatives Dem/Val.
- Continue NBC Initiatives EMD.
- Continue Air Warrior EMD.

FY 00 Milestones:
- Continue Air Warrior EMD; build 200 prototypes; conduct IOTE.

FY 01 Milestones:
- Complete Air Warrior Block I EMD; Conduct Milestone III and begin LRIP.
- Initiate AW Block II EMD.

AVIATION GROUND SUPPORT EQUIPMENT (AGSE)

Requirements

The AGSE R&D program is to enhance utilization of current and future aircraft by improving the efficiency of maintenance and servicing operations. The primary requirements are: to replace obsolete, insupportable ground support equipment with new and standardized multi-output equipment compatible with all Army aircraft models; develop rapid battle damage repair procedures and tools to speed the return of aircraft to combat ready status; develop new equipment for aerial recovery of damaged aircraft; and to develop new procedures, tools, and maintenance aids (especially in the area of diagnostics and prognostics) to improve the efficiency, reliability, and tracking of aircraft maintenance and repairs. The OCRs which track to Army aviation AGSE requirements are associated with the CSS battlefield dynamic. These include recovery of combat damaged vehicles, efficiency and reliability of repairs, and tracking/visibility of the logistics supply chain.

Goals

Currently, Army aviation maintenance units are burdened with outmoded and aircraft peculiar tools and equipment that are not compatible with the modernized aircraft being procured or planned for the future. The objective of the Advanced Maintenance Concepts and Equipment project are to replace all obsolete (1950s and 1960s vintage) specialized tools and support equipment with new standardized equipment that are compatible with all Army aircraft. Additionally, there is an opportunity to exploit the ever increasing level of integrated electronics and systems architecture of the aircraft and advances in computer processing and knowledge based/artificial intelligence systems. The application of on-board and portable diagnostics and prognostics, electronic repair manuals, and automated log books will enable aircraft maintainers to more rapidly and efficiently detect, isolate, and repair faulty or damaged components.

Strategy

The strategy for developing and acquiring AGSE maximizes the use of Non-Developmental Items (NDI) whenever possible. This also includes items being developed and/or procurred by the other services to take advantage of opportunities for cost sharing and joint programs. The Aviation S&T program also transitions new concepts and technologies for specific applications to AGSE and logistics requirements.

The primary focus of the supporting S&T, as discussed earlier (page 51), is on developing prognostic and diagnostic knowledge bases, and composite, fiber optic and low observable material repair. The Advanced Boresight Equipment (ABE) program is a joint effort with the Navy and Air Force to develop common boresight equipment for multiple aircraft types. Its reduced size and ease of set up will greatly improve boresighting accuracy, reduce aircraft

down time, and reduce manpower, logistical and mobility burdens associated with the current methods of boresighting. The Soldier Portable On-System Repair Tool (SPORT), Shop Equipment-Contact Maintenance (SECM), Intelligent Fault Locator (IFL), Helicopter Usage Monitoring System (HUMS), Turbine Engine Diagnostic System (TEDS), and the family of Combat Maintenance/Battle Damage Repair (CM/BDR) kits address maintenance diagnostics and repair needs. The Maintenance Free Battery and Environmental Sensitive Maintenance programs address the need for improved maintenance techniques, procedures, and supporting items to reduce environmental hazards and reduce maintenance/replacement requirements. The Unit Maintenance Aerial Recovery Kit (UMARK) is an effort to developing a stronger, lightweight sling for the recovery of downed aircraft via the CH-47D or CH-53. The Belvoir RDEC and Project Manager for Petroleum, Water, and Lubricants (PM-PWL) are developing the Advanced Aviation Forward Area Refueling System (AAFARS). Together with the sideloader and rearming concepts proven under the Logistics Rearmament-Aviation TD, aviation will be able to significantly reduce FARP cycle times. The R&D strategy for AGSE is illustrated in the Figure 46 roadmap for AGSE and Cargo Handling Equipment.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Demonstrated Non-Destructive Inspection/Non-Destructive Test (NDI/ NDT) prototype hardware and initiated final design.
- Completed development, test and demonstration of CM/BDR kit for fiber optic systems.
- Completed detailed design, fabricated hardware, and conducted static lift tests of UMARK.
- Initiated design, fabrication and integration of ABE pre-production units.
- Successfully demonstrated ABE prototype on AH-64A, MH-60K, MH-47E, F-15C/E, F/A-18, and SA-362 aircraft.
- Completed evaluation and finalized design of SECM.
- Interfaced electronic Apache Technical Manual (TM) repair procedures with the IFL and investigated active bus interface diagnostic methods.

During FY95, the following program milestones were achieved:

- Initiated UMARK EMD. Conducted development and operational test of UMARK.
- Automated NDI/NDT inspection methods and repair procedures through application of knowledge based software.
- Continued fabrication and integration of ABE pre-production units. Completed Dem/Val Critical Design Review for pre-production prototype unit.
- Successfully demonstrated ABE prototype on MH-60K and MH-47E aircraft. Supported SOA flight test program
- Initiate design of a new single configuration AVIM Shop Set Complex.
- Continue production engineering support for Flexible Engine Diagnostic System (FEDS).
- Completed Logistics Rearm TD for Aviation - demonstrated faster, more efficient FARP and AH-64 rearming.

Milestones

Major technical and program milestones in the AGSE project in the FY 96-01 POM period include:

FY 96 Milestones:

- Demonstrate knowledge based automated NDI/NDT inspection and repair procedures for composite components.
- Initiate a Dem/Val program for a comprehensive on-board diagnostics system interfaced with an automated maintenance and logistics system.
- Complete Dem/Val phase of ABE program.

- Initiate a program to explore high reliability, low maintenance alternatives to nickel-cadmium batteries.
- Initiate development of Advanced Portable Maintenance Aid for hand-free interface with maintenance procedures and instructions.
- Develop and demonstrate environmentally sensitive options for aircraft maintenance.

FY 97 Milestones:

- Initiate development of field repair capability for low observable components.
- Complete detailed design of on-board diagnostics system and define interface with automated maintenance and logistics system.
- Assemble the Advanced Portable Maintenance Aid and initiate a field demonstration.
- Conduct field evaluations of nickel-cadmium battery alternatives.
- Demonstrate environment friendly alternatives for aircraft maintenance issues.

FY 98 Milestones:

- Complete HUMS assessment.
- Complete Maintenance Free Battery program.
- Complete TEDS EMD and Milestone III.

FY 99 Milestones:

- Continue development of LO Composite CM/BDR kit.
- Continue demonstration and assessment of environment friendly alternatives for aircraft maintenance issues.
- Initiate Future Aviation Logistics program.

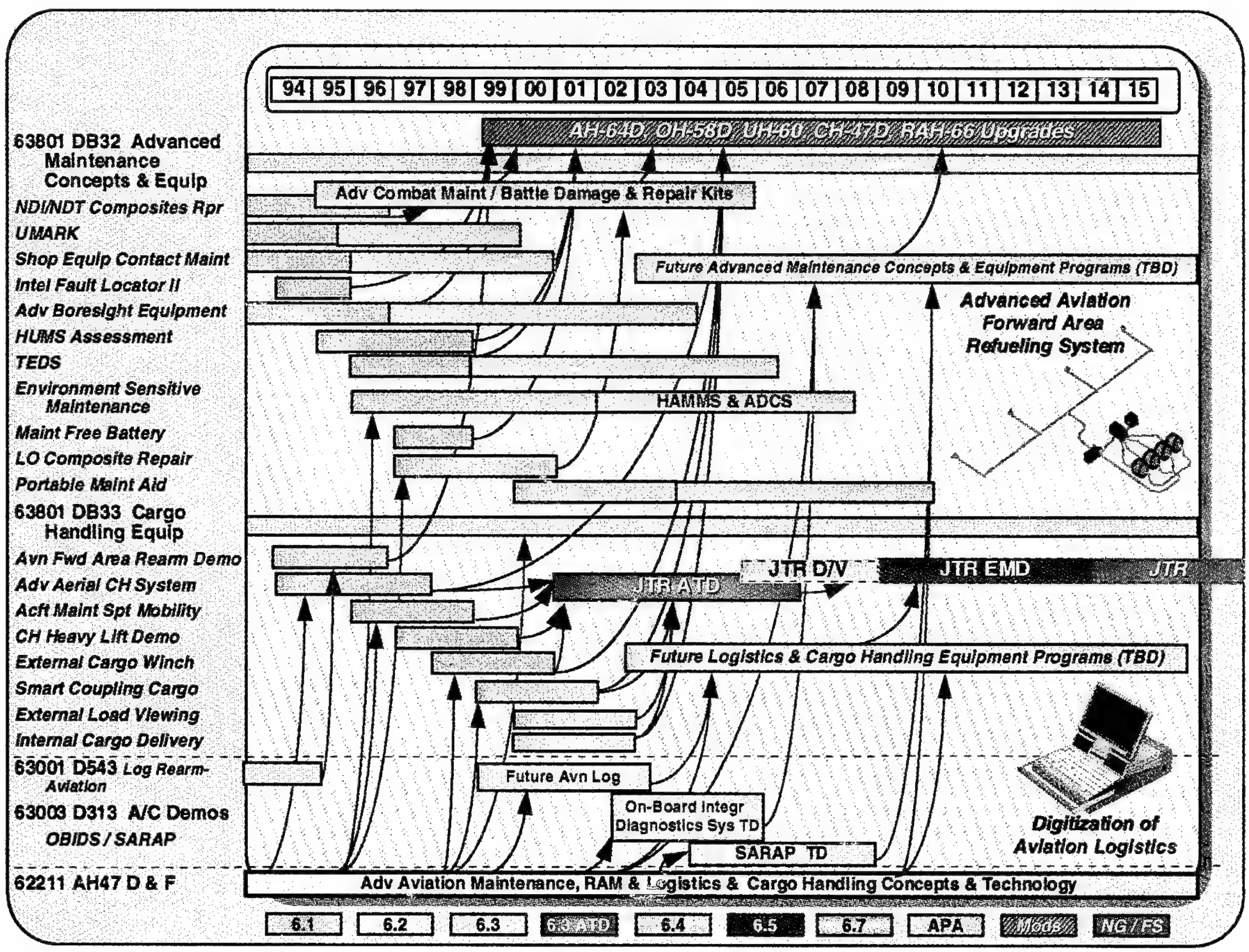


Figure 46. Aviation Ground Support Equipment & Cargo Handling EquipmentR&D Roadmap.

FY 00 Milestones:

- Initiate Dem/Val of Portable Maintenance Aid.
- Complete LO Composite CM/BDR kit EMD.

FY 01 Milestones:

- Complete demonstrate and assessment of environment friendly alternatives for aircraft maintenance.

CARGO HANDLING EQUIPMENT (CHE)

Requirements

The CHE R&D program is to develop equipment and operational improvements in loading and off-loading helicopter cargo in all-weather, around the clock combat scenarios. Improvements to standardize and enhance loading procedures, pallets, cargo nets and slings, cargo acquisition, movement and delivery, and increase cargo helicopter productivity are required to optimize and streamline aerial cargo throughput on the fast-paced, non-linear battlefield. Many of these improvements are required to support the Improved Cargo Helicopter and JTR, as stated in the draft requirement for the ACT. This project supports OCRs from the CSS Battle Lab.

Goals

The objective of the CHE R&D project is to develop affordable, productivity enhancing items of support equipment for cargo aircraft and cargo handlers. Goals are to reduce cargo loading and unloading times, increase cargo throughput, and reduce manpower requirements.

Strategy

The strategy for developing and acquiring CHE includes NDI, joint service, and technology transition form the aviation S&T program. Current programs and plans are focused on developing improved and standardized internal and external cargo systems to meet requirements for the CH-47D, ICH, and JTR. Systems are to be designed to maximize the transfer of cargo between Army aircraft, Air Force cargo transports (C-5, C-17, C-130) as well as ground transporters/trucks. The approach is to integrate technologies and concepts from the S&T program for cargo handling qualities, structures and materials programs, and Air Force and commercial developments. Additionally, this project is being utilized to support the Logistics Rearmament-Aviation and Advanced Forward Area Refueling and Rearming Point (FARP) demonstrations in coordination with the ARDEC, BRDEC, and the PM-PWL. The AGSE and CHE roadmap is shown at Figure 46.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- Conducted functional test for improved 30mm Ammo Loader and demonstrated rapid (15 minutes) turnaround FARP.
- Contract award and initiated design of Advanced Aerial Cargo Handling System to enhance cargo helicopter productivity.
- Completed design, fabrication and support testing of Advanced Material External Cargo Sling leg.

During FY95, the following program milestones were achieved:

- Completed design, fabrication and bench test of a pre-production prototype of 30mm Ammo Loader compatible with weight goals for the AH-64A and AH-64D.
- Defined Advanced Cargo Handling Systems preliminary design.
- Completed detail design and initiated fabrication of advanced internal and external cargo handling system.

Milestones

Major technical and program milestones in the CHE project in the FY 96-01 POM period include:

FY 96 Milestones:
- Initiate definition of a high-mobility transport system for aircraft maintenance units.
- Complete fabrication and installation of advanced internal and external cargo handling systems and demonstrate impact on cargo aircraft productivity.

FY 97 Milestones:
- Complete demonstration of advanced internal and external cargo handling systems.
- Initiate Dem/Val for a high performance, lightweight, external cargo winch.
- Initiate demonstration of a cargo movement system for heavy (95 percentile) loads.
- Continue aircraft maintenance unit mobility system definition.

FY 98 Milestones:
- Initiate Smart Coupling Cargo program.
- Complete heavy cargo movement demonstration.

FY 99 Milestones:
- Initiate External Cargo Viewing program.
- Initiate Internal Cargo Delivery demonstration.

FY 00 Milestones:
- Continue External Cargo Viewing program.
- Continue Internal Cargo Delivery demonstration.

FY 01 Milestones:
- Complete External Cargo Winch Dem/Val.
- Continue External Cargo Viewing program.
- Continue Internal Cargo Delivery demonstration.

AIR TRAFFIC CONTROL (ATC)

Requirements

The ATC project provides for development of both tactical and fixed base ATC equipment to support the Army airspace management mission. The most urgent requirements for ATC are to replace obsolete (1950 to 1970 vintage) tactical and fixed base ATC equipment, provide the Force XXI battlefield with automated Army Airspace Command and Control (A2C2) planning, enhanced A2C2 execution, integration into the digital battlefield, improved theater and intra-/inter-corps and division Air Traffic Services (ATS) support in war, a versatile airspace management system for OOTW, meet mobility and deployability requirements of contingency operations, and to satisfy federal and international mandates for fixed base ATC facilities. Much of the ATS/ATC equipment currently in the field is becoming unsupportable, lacks the mobility and deployability required, is not compatible with the digitization initiative, and does not meet FAA regulations and mandates.

Improved systems are urgently required to provide A2C2 communications and precision and non-precision approach and enroute capability in support of Army tactical airfields, remote landing zones, drop zones, pickup zones and temporary helicopter operating areas worldwide. The Tactical Terminal Control System (TTCS), Air Traffic Navigation, Integration and Coordination System (ATNAVICS), Tactical Airspace Integration System (TAIS), and Mobile Tower System (MOTS) are NDI efforts to meet these requirements. Fixed base efforts include the Fixed Base Precision Approach Radar (FBPAR), Navigation Air Systems Modernization (NAVAID), Communication System Modernization, and National Air Space (NAS) integration and digitization of the ATC structure address the issues of obsolescence and FAA requirements.

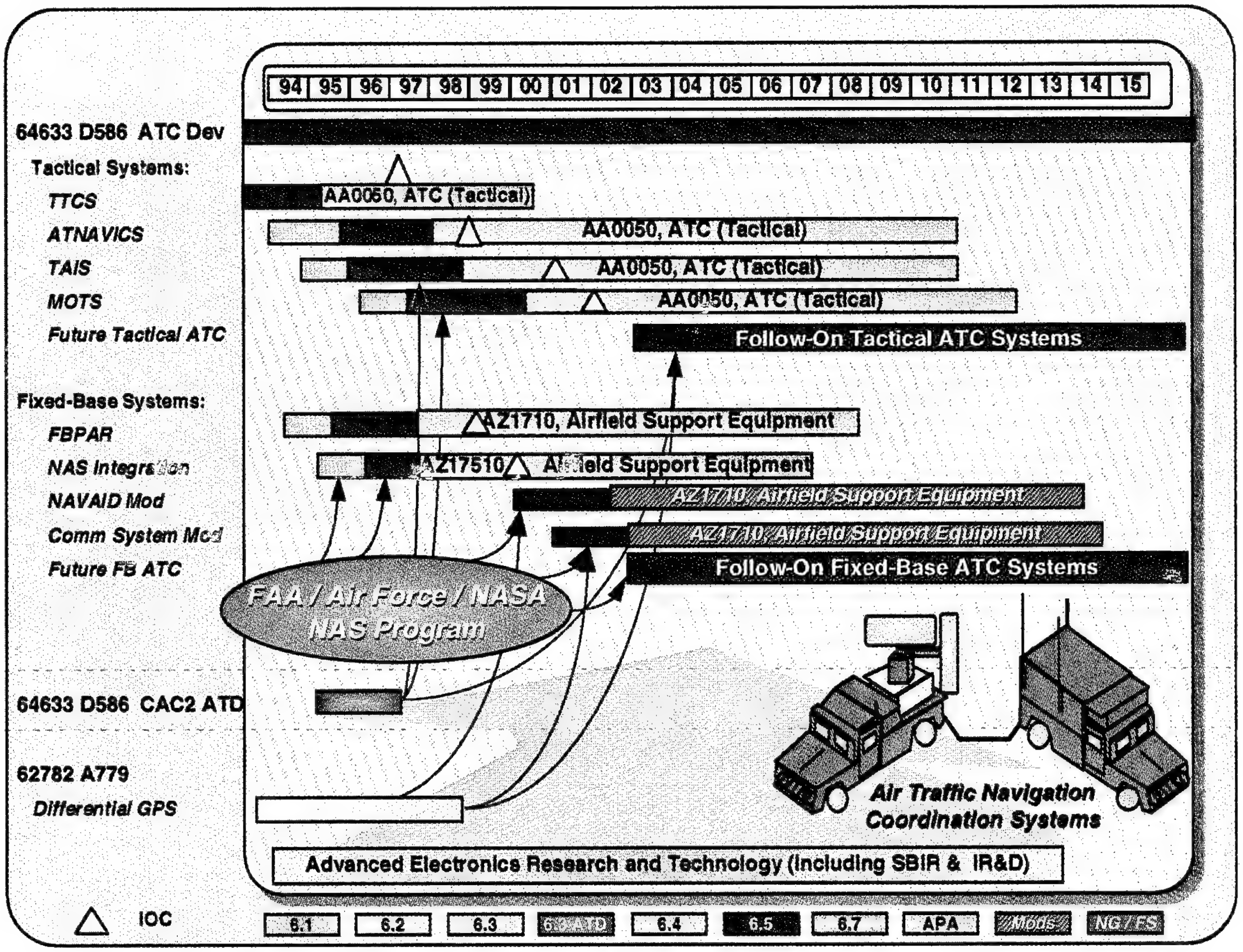


Figure 47. Air Traffic Control R&D Roadmap.

Goals

The primary objective of the ATS/ATC R&D effort is to develop and acquire cost effective, state-of-the-art, digitally compatible systems to meet force projection modernization requirements by replacing the outdated tactical and fixed base systems.

Strategy

The ATC R&D program is exploiting NDI solutions to maximize the return on investment of very limited funds. Fixed base efforts are closely coordinated with the FAA and other services. Wherever possible, systems and concepts are developed by the FAA and other services are exploited for Army use. Tactical ATS programs are extensively borrowing from the C2 and digitization efforts, using common software, communications, C2 components, processors, navigation aids, and tactical hardware and vehicles to ensure system compatibility, interoperability and integration.

Although the ATC systems are NDI off-the-shelf items, all of the systems are subject to feeder technologies that require RDT&E. Such technologies may include but are not limited to the Differential Global Positioning System (GPS) to support the communicaton and navigational system upgrades. Figure 47 illustrates the ATC modernization strategy.

FY 94 and FY 95 Accomplishments

During FY 94, the following program milestones were achieved:

- TTCS contract awarded (10 systems with 2 options for 26 each).

- Conducted evaluation and suitability study for ATNAVICS/FBPAR.
- Conducted market analysis and design definition/integration analysis for TAIS.

During FY95, the following program milestones were achieved:

- Conducted TTCS critical design review.
- Conducted developmental and operational limited users test.
- ATNAVICS/FBPAR contract award.
- Complete design/system integration for TAIS with Army communications hardware/ software for digitization integration analysis.
- Conducted TAIS hardware and software demonstration.
- Initiated TAIS evaluation and suitability study.
- Conducted TAIS Milestone I/II review.
- Initiated NAS Integration Dem/Val.
- Conducted NAS Milestone II review.

Milestones

Major technical and program milestones in the ATC project in the FY 96-01 POM period include:

FY 96 Milestones:

- Initiate ATNAVICS EMD.
- Conduct ATNAVICS/FBPAR system performance test.
- Conduct TAIS Milestone I/II review.
- TAIS contract award/production option.
- Complete TAIS suitability study.
- Initiate TAIS EMD.
- NAS first unit equipped (Army fixed site).

FY 97 Milestones:

- Procure prototype TAIS for developmental testing and initial operational test evaluation.
- Design, fabricate, and test TAIS prototype.
- MOTS Milestone I/II review.
- Design and fabricate MOTS prototype.
- NAS and FBPAR miestone III reviews.
- Accept ATNAVICS/FBPAR prototypes.
- Conduct IOT&E for ATNAVICS/FBPAR.

FY 98 Milestones:

- Complete ATNAVICS Milestone III.
- ATNAVICS first unit equipped.

FY 99 Milestones:

- TAIS first article test.
- MOTS developmental and operational tests.

FY 00 Milestones:

- TAIS first unit equipped.
- MOTS Milestone III review.
- NAS IOC.
- Initiate NAVAID Modernization program.

FY 01 Milestones:

- MOTS first article test.

Initiate Communication Modernization program.

ENGINE COMPONENT IMPROVEMENT PROGRAM (CIP)

Requirements

As various Army aircraft engine models and series (T700, T55, T53, GTCP36, T703, and, eventually, the T800) have been fielded with Army aircraft, service related issues arise which require expeditious solutions to ensure the safety and readiness of the fleet. Also, factors such as changes in mission requirements and operational environment, environmental concerns, cost and availability of strategic materials, and emergence of exploitable new technologies that can reduce O&S costs and improve durability, reliability, and readiness require a vigorous engine improvement program.

The Aircraft Engine CIP develops, tests, and qualifies improvements to aircraft engine components to correct service revealed deficiencies, improve safety, enhance readiness, and reduce O&S costs for military engines. The Engine CIP program also includes redesign, test, and requalification of engine components

identified as part of the Army's flight safety parts service life surveillance program. The tri-service engine CIP is funded under RDT&E by direction of Congress.

Goals

The main goal is to provide the technical and engineering expertise and services necessary to address safety and readiness requirements as they arise in the field, and to reduce the cost of ownership of turbine engines.

Strategy

The Engine CIP strategy (Figure 48) incorporates a coordinated tri-service, foreign military, and commercial effort to identify and prioritize turbine engine CIP requirements. Solutions to deficiencies, safety issues, readiness shortfalls, and O&S costs are drawn from the S&T program and commercial sources. Application of proven advanced technologies in alloys and other metals and composites, bearings, combustors, compressors, turbomachinery and the basic sciences (such as CFD, heat transfer, and thermodynamics) are made to resolve these requirements.

The Aircraft Engine CIP program is closely coordinated with the other services, FMS customers, and industry to minimize duplication of effort and to maximize the return on investment through application to U.S. military, FMS, and civil aircraft engines.

FY 94 and FY 95 Accomplishments

During FY 94, the following program

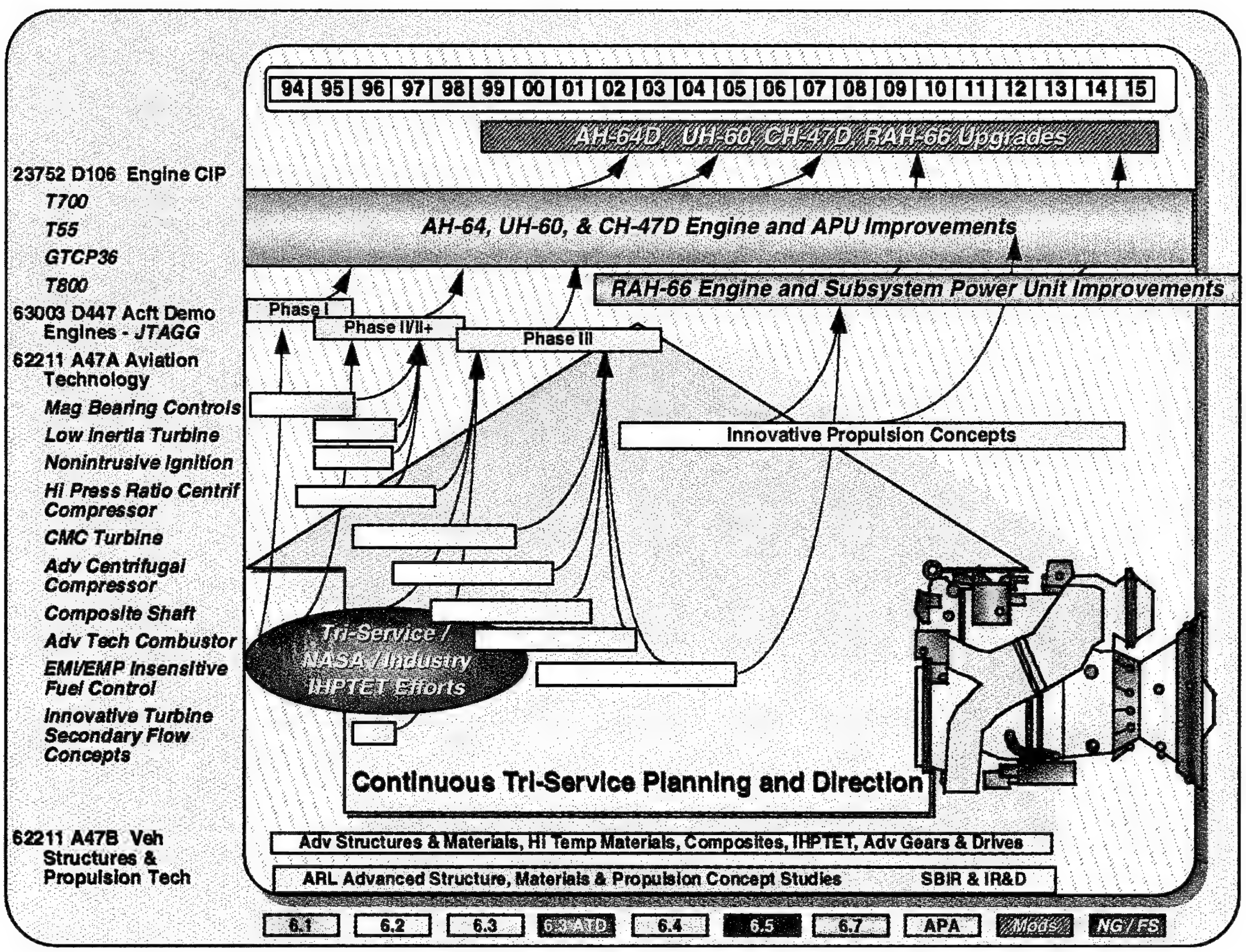


Figure 48. Aircraft Engine CIP Investment Strategy and Roadmap.

milestones were achieved:

- **T700 Engine:**
  - *Continued update of life limits on components using improved analytic & modeling technique.*
  - *Continued design & testing of improved Digital Electronic Control Unit (DECU) with enhanced EMI operability.*
  - *Redesigned & tested a more contamination resistant hydromechanical unit to prclude engine failures.*
  - *Performed altitude testing of lowered start fuel flow schedule to evaluate impact on engine starting with below minimum required torque.*

- **T55 Engine:**
  - *Continued design/development of inlet housing in composite materials.*
  - *Began bearing improvement program to reduce cost and improve reliability & fatigue life.*
  - *Began design/development of machined combustor liner for improved durability.*
  - *Designed cast 4th nozzle to replace fabricated nozzle to improve durability & survivability and reduce O&S costs.*
  - *Began pinned first turbine blade program to preclude turbine blades from shifting into turbine nozzle and resultant catastrophic failure.*
  - *Began number one seal redesign to reduce accessory gearbox pressure and reduce cost.*

- **GTCP36 APU:**
  - *Designed improved clutch for Apache APU to preclude catastrophic failures that have resulted in fires/destruction of AH-64 aircraft.*

During FY95, the following program milestones were achieved:

- **T700 Engine:**
  - *Continued update of life limits on components.*
  - *Continued qualification testing of improved DECU with enhanced EMI operability.*
  - *Complete program to reduce stiction in torquemeter design by using better sealing of power turbine shaft and reducing reference shaft stiffness.*
  - *Complete program to test & qualify a more contamination resistant hydromechanical unit.*

- **T55 Engine:**
  - *Continue bearing improvement program.*
  - *Continue machined combustor liner program.*
  - *Continue pinned first turbine blade program.*
  - *Designed improved compressor impeller to improve efficiency and reduce cost.*

- **GTCP36 APU:**
  - *Complete redesign & qualification testing of clutch for Apache APU.*

Milestones

Major technical and program milestones in the Engine CIP in the FY 96-01 POM period include:

FY 96 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Complete qualification testing of improved DECU with enhanced EMI operability.*
  - *Initiate development/qualification of improved booster pump that is less susceptible to air ingestion - reducing engine flameouts.*
  - *Continue update of mission profiles used in life analysis by gathering field data.*
  - *Redesign & test new IPS blower shaft with improved torsional resilience to impact torque to preclude shaft failures.*

- **T55 Engine:**
  - *Continue bearing improvement program.*
  - *Conclude machined combustor liner program.*
  - *Conclude pinned first turbine blade program.*
  - *Continue development of improved compressor impeller.*

- **GTCP36 APU:**
  - *Design improved ring gear retainer to preclude disengagement & failure to start the APU, improve readiness, & reduce O&S cost.*
  - *Develop electronic control unit fault isolation procedures for the Blackhawk APU to preclude unnecessary removals, improve readiness, and reduce O&S cost.*

- *Test improved split bearing for planetary gear set on Apache APU to preclude vibration induced failures, improve reliability, and reduce O&S cost.*

FY 97 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Complete development/qualification of improved booster pump.*
  - *Complete update of mission profiles used in life analysis by gathering field data.*
  - *Improve A-sump pressurization to eliminate oil leakage and maintain cleanliness of compressor & performance retention.*
  - *Redesign gas generator accelerator to reduce gas generator components cooling - resulting in improved component life and reduced costs.*

- **T55 Engine:**
  - *Concludee bearing improvement program.*
  - *Conclude improved compressor impeller program.*
  - *Develop fireproof fuel and oil lines to bring them up to current safety standards.*
  - *Redesign turbine components to eliminate need for rare and obsolete alloy.*

- **GTCP36 APU:**
  - *Redesign & qualify planetary sun gear on Blackhawk APU to reduce gear loading, improve durability & reliability, and reduce O&S cost.*

FY 98 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Investigate compressor airfoil erosion resistant coatings that minimize erosion when exposed to sand environment - increase engine life and reduced costs.*
  - *Initiate design, test & qualify a reduced leakage compressor discharge pressure (CDP) brush seal to maintain performance and increase engine installed life.*

- **T55 Engine:**
  - *Begin EMI/EMP protection program for ignition system and overspeed valve.*
  - *Continue redesign and qulification of turbine components to eliminate need for rare and obsolete alloy.*

- **GTCP36 APU:**
  - *Design a ceramic turbine nozzle for all GTCP36 APUs to reduce erosion/improve sand tolerance, improve readiness/durability/ service life, and reduce O&S costs.*

FY 99 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Complete qualification of erosion resistant compressor airfoil coating.*
  - *Complete design, test & qualification of a reduced leakage CDP brush seal.*
  - *Continue program to develop procedures and tooling to enhance the field's Line Replaceable Unit (LRU) diagnostic capability.*

- **T55 Engine:**
  - *Continue EMI/EMP protection program for ignition system and overspeed valve.*
  - *Begin composite material integration for a variety of components (#1 bearing liner, oil tank baffle, output housing) to reduce weight and O&S costs.*

- **GTCP36 APU:**
  - *Continue design and initiate development testing of ceramic turbine nozzle for all GTCP36 APUs.*

FY 00 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Complete program to develop procedures and tooling to enhance the field's Line Replaceable Unit (LRU) diagnostic capability.*
  - *Redesign the yellow harness to improve it's EMI shielding and improve connector bonding to enhance EMI capability.*
  - *Initiate redesign, test, and qualification of improved efficiency centrifugal compressor for higher production margin and longer installed engine life.*

- **T55 Engine:**
  - *Continue composite material integration for a variety of components.*
  - *Begin design & qualification of cast air diffuser to reduce acquisition and O&S costs, and improve stability margin of engine.*

- **GTCP36 APU:**
  - *Complete qualification testing of ceramic turbine nozzle for all GTCP36 APUs.*

FY 01 Milestones:

- **T700 Engine:**
  - *Continue update of life limits on components.*
  - *Continue improved efficiency centrifugal compressor program.*

- **T55 Engine:**
  - *Continue composite material integration for a variety of components.*
  - *Continue design & qualification of cast air diffuser.*
  - *Begin program for single high speed gearbox to reduce weight and O&S costs.*

- **GTCP36 APU:**
  - *Design a common digital control for Blackhawk and Longbow Apache to reduce O&S costs and improve readiness by eliminating nee for separate controls for the Blackhawk and Apache APUs.*

- **T800 Engine:**
  - *Initiate CIP for the T800 if warranted.*

CONCLUSION

The preceeding discussion of ou aviation RDT&E programs was not intended to be all inclusive and exhaustively detailed. However, it is our intent to provide our customers and partners in the aviation community with a sense of the direction that technology and requirements are taking Army aviation. There are many opportunities to exploit technology, and there is still considerable work ahead to meet the requirements of the future as envisioned for Force XXI. We do not presuppose that the programs described are the only solutions. There are numerous ideas and technologies still evolving which may provide solutions to critical capabilities for Army aviation. As we learn more about integrating the combined arms on the digital battlefield and evolve towards Force XXI, new requirements and capability issues will be discovered. Therefore, it is imperative that we expand the concept of IPTs, IPPD, cooperative programs, and open dialogue to make the most of the resources available within DoD, Industry, and academia to ensure that the American soldier is suitably equipped to meet the challenge.

ACKNOWLEDGEMENTS

Thanks to all who have contributed to this Plan. Not only those within the AVRDEC, but also to all those in the PEO-AV, throughout ATCOM (AFDD, AATD, IMMC, PMs, and WSMs), AVNC, ARDEC, CERDEC, NRDEC, MRDEC, TARDEC, STRICOM, PEO-IEW, PEO-C3S, NASA, and our contractors. It was their expertise and efforts which make a Plan like this possible.

Our staff would like to hear from you and are willing to answer any questions you may have on the content of the 1996 Army Aviation RDT&E Plan. If there are any questions or comments on specific RDT&E efforts discussed in this Plan, please contact the Directorate for Advanced Systems, DSN 693-1070 or commercial (314) 263-1070. If they cannot provide a suitable answer, they can put you in contact with the proper program manager or technical area subject matter experts. Any proposed improvements or corrections to the Plan should be directed to the Mission Area Management Division, Directorate for Advanced Systems at DSN 693-2275/1433 or commercial (314) 263-2275/1433.

APPENDIX A: ACRONYMS LIST

2

2d	two-dimensional

3

3D	three-dimensional
3rd GARD	Third Generation Advanced Rotor Design

A

A2C2	Army Airspace Command and Control
A2C2S	Army Airborne Command and Control System
AAFARS	Advanced Aviation Forward Area Refueling System
AAMP	Army Aviation Modernization Plan
AARFE	Advanced Active Radio Frequency Expendable
AATD	Aviation Applied Technology Directorate
ABE	Advanced Boresight Equipment
ACS	Aerial Common Sensor
ACT	Advanced Cargo Transport
ACT	Apache Crew Trainer
ACTD	Advanced Concept Technology Demonstration
ACUS	Area Command User System
AD	advanced development
ADDS	Army Digitized Data System
ADS	Advanced Dispenser System
ADS	Aeronautical Design Standard
AEC-PMO	Aviation Electronic Combat Project Management Office
AF	Air Force
AFDD	Aeroflightdynamics Directorate
AGSE	Aviation Ground Support Equipment
AHP	Advanced Helicopter Pilotage
AI	artificial intelligence
AI2	Advanced Image Intensification
AIHS	Aircrew Integrated Helmet System
AIPSYS	Advanced Integrated Pilotage System
AIRCMM	Advanced Infrared Countermeasure Munition
ALERT	Air/Land Enhanced Reconnaissance and Targeting
ALSE	Aviation Life Support Equipment
AMC	Army Materiel Command
AMCS	Aircrew Microclimatic Conditioning System
AMP	Army Modernization Plan
AMPS	Aviation Mission Planning System
ANVIS	Aviator's Night Vision Intensification System
APU	Auxillary Power Unit
ARDEC	Armaments Research, Development and Engineering Center
ARES	Aeroelastic Rotor Experimental System

ARI	Aviation Restructure Initiative
ARL	Airborne Reconnaissance - Low
ARL	Army Research Laboratory
ARPA	Advanced Research Projects Agency
ART	Advanced Rotocraft Transmission
ASA	Aviation Systems Architecture
ASBREM	Armed Services Biomedical Research, Evaluation and Management Committee
ASE	Aircraft Survivability Equipment
ASR	Acquisition Strategy Report
ASRAO	Advanced Systems Research and Analysis Office
ASRT	Autonomous Scout Rotorcraft Testbed
ASSH	Aircraft System Self-Healing
ATA	air-to-air
ATASK	Air-To-Air Starstreak
ATC	Air Traffic Control
ATCOM	U.S. Army Aviation and Troop Command
ATD	Advanced Technology Demonstration
ATG	air-to-ground
ATIRCM	Advanced Threat IR Countermeasures
ATIRJ	Advanced Threat Infrared Jammer
ATNAVICS	Air Traffic Navigation, Integration, and Coordination System
ATR	Aided Target Recognition
ATRJ	Advanced Threat Radar Jammer
ATRWR	Advanced Threat Radar Warning Receiver
ATS	Air Traffic Services
AV or Avn	aviation
AVCATT	Aviation Combined Arms Tactical Trainer
AVNC	Aviation (Warfighting) Center
AVRDEC	Aviation Research, Development and Engineering Center
AVTOC	Aviation Tactical Operations Center
AW	Air Warrior
AWE	Advanced Warfighting Experiment
AWIP	Advanced Weapons Integration Program

B

BC	Battle Command
BCID	Battlefield Combat Identification
BDA	Battle Damage Assessment
BeAl	berylium-aluminum
BL	Battle Laboratory
BLWE	Battle Lab Warfighting Experiment
BOS	Battlefield Operating System
BRDEC	Belvoir Research, Development and Engineering Center (now defunct)
BVI	blade vortex interaction

C

C2	command and control
C2V	Command and Control Vehicle
C3I	command, control, communications, and intelligence

C4	command, control, communications and computers
CABS	Cockpit Air Bags System
CAC2	Combined Arms Command and Control
CASTFORM	Combined Arms and Support Task Force Evaluation Model
CB	chemical and biological
CBDCOM	U.S. Chemical and Biological Defense Command
CDP	compressor discharge pressure
CECOM	U.S. Army Communications-Electronics Command
CERDEC	Communications and Electronics Research, Development and Engineering Center
CFD	Computational Fluid Dynamics
CFT	captive flight test
CH	cargo handling
CHE	Cargo Handling Equipment
CHPR	Cooper-Harper Pilot Rating
CHS	Common Hardware/Software
CIFER	Comprehensive Identification of Frequency Response
CIP	Component Improvement Program
CM	countermeasures
CM/BDR	Combat Maintenance/Battle Damage Repair
CMC	ceramic matrix composite
CMWS	Common Missile Warning System
CNR	Combat Net Radio
CONDOR	Covert Night/Day Operations in Rotorcraft
CPTIG	Cockpit Procedures Trainers with Image Generator
CRBES	Composite Rotor Blade Erosion Protection System
CRDA	Cooperative Research and Development Agreement
CSMET	Crew Station Mission Equipment Trainer
CSRDF	Crew Station Research and Development Facility
CSS	Combat Service Support
CTAGT	Cartridge, Air-to-Ground, Training

D

D&SA	Depth and Simultaneous Attack
DAB	Defense Acquisition Board
db	decibel
DBS	Dismounted Battle Space
DDR&E	Director of Defense Research and Engineering
DE	directed energy
DEA	Data Exchange Agreement
DECU	Digital Electronic Control Unit
Dem/Val	Demonstration/Validation
DEW	directed energy weapons
DGNS	Doppler embedded GPS Navigation System
DIS	Distributed Interactive Simulation
DNW	Deutschland-Nederlanders Windcanal (German-Dutch Windtunnel)
DoD	Department of Defense
DT	developmental test
DT&E	Developmetal Test and Evaluation

E

ECCM	electronic counter-countermeasures
ECIT	Enhanced Communications Interface Terminal
ECP	Engineering Change Proposal
ED	engineering development
EELS	Early Entry Lethality and Survivability
EGI	Embedded GPS/INU
EMD	engineering and manufacturing development
EMI	electro-magnetic interference
EMP	electromagnetic pulse
EO	electro-optics
EOC	early operational capability
EPP	Extended Planning Period
ERDEC	Edgewood Research, Development and Engineering Center
ES	expert system
ESJ	Escort/Standoff Jammer
EUTE	Early User Test and Evalution
EW	electronic warfare
EW	empty weight

F

FAA	Federal Aviation Administration
FAAV	Future Attack Aerial Vehicle
FADEC	full authority digital electronic control
FARP	Forward Area Refueling Point
FARRP	Forward Area Refueling and Rearming Point
FAST	Future Ammunition Science and Technology
FB	fixed base
FBPAR	Fixed Base Precision Approach Radar
FBW	fly-by-wire
FCR	Fire Control Radar
FCS	flight control system
FEDS	Flexible Engine Diagnostic System
FLIR	forward looking infrared
FMS	Foreign Military Sales
FOM	figure of merit
FSTP	Full Spectrum Threat Protection
FUE	first unit equipped
FUR	Future Utility Rotorcraft
FY	fiscal year

G

GAMM	Generalized Air Mobility Model
GE	General Electric
GPS	Global Position System
GW	gross weight

H

HACT	Helicopter Active Control Technology

HARS	Heading Altitude Reference System
HBCU/MI	Historically Black Colleges and Universities/Minority Institutions
HDU	Helmet Display Unit
HF	high frequency
HIP	
HMD	helmet-mounted display
HQ	handling quality
HQ	Have Quick
HQDA	Headquarters, Department of the Army
HSI	Human Systems Interface
HSIM	Helicopter Structural Integrity and Monitoring
HTI	Horizontal Technology Insertion
HUMS	Helicopter Usage Monitoring System
HWIL	hardware in the loop

I

I2	image intensification
I2R or IIR	imaging infrared
IAMT	Improved Airframe Manufacturing Technology
IBAHRS	Integrated Body And Head Restraint System
ICH	Improved Cargo Helicopter
ID	identification
IDM	Improved Data Modem
IEA	Information Exchange Agreement
IEW	intelligence and electronic warfare
IFFC	Integrated Fire, Flight (and fuel) Control
IFL	Intelligent Fault Locator
IHPTET	Integrated High Performance Turbine Engine Technology
ILIR	Independent Laboratory Innovative Research
IMCPU	Improved Master Controller Processing Unit
INFAC	Instrumented Factory
INU	Inertial Navigation Unit
IOC	initial operational capability
IOT&E	Initial Operational Test and Evaluation
IPPD	Integrated Product and Process Development
IPS	Inlet Protection System
IPT	Integrated Product Team
IR&D	Independent Research and Development
IRCM	Infrared Countermeasures

J

JACG	Joint Aeronautical Commanders Group
JAST	Joint Air Strike Technology
JCABS	Joint Cockpit Air Bag System
JCIT	Joint Communication Interface Terminal
JDL	Joint Directors of Laboratories
JIAWG	Joint Integrated Avionics Working Group
JIWG	Joint Integration Working Group
JLC	Joint Logistics Commanders

JTAGG	Joint Turbine Advance Gas Generator
JTCG	Joint Technical Coordination Group
JTCG/AS	Joint Technical Coordination Group for Aircraft Survivability
JTR	Joint Transport Rotorcraft

K

KBS	knowledge base system
kW	kilowatt

L

LAM	Louisiana Maneuvers
LBA	Longbow Apache
LCPK	Low Cost Precision Kill
LCT	Longbow Apache Crew Trainer
LFT&E	Live Fire Test and Evaluation
LL	long lead
LO	low observables
LRIP	low-rate initial production
LRU	line replaceable unit
LUT	Limited User Test

M

M&S	modeling and simulation
MAH	assigned manned helicopter
MANPRINT	Manpower and Personnel Integration
MASTER	Manufacturing and Structures Technology for Efficient Rotorcraft
MBS	Mounted Battle Space
MCS	Maneuver Control System
MDEP	Management Decision Package
MDPS	materials/displays/processors/sensors
MEP	Mission Equipment Package
MICOM	U.S. Army Missile Command
MIDAS	Man-machine Integrated Design and Analysis System
MIL-STD	military standard
MISSFM	Miniture In-Situ Smart Fatigue Monitor
MMA	Mast-Mounted Assembly
MMW	millimeter wave
MOA	Memorandum of Agreement
MOOTW	Military Operations Other Than War
MOPP	Mission Operational Protection Posture
MOTS	Mobile Tower System
MOU	Memorandum of Understanding
MP&S	Materials, Process and Structures
MRDEC	Missile Research, Development and Engineering Center
MRMAAV	Multi-Role Mission Adaptable Air Vehicle
MS&T	Manufacturing Science and Technology
MSAT-Air	Multi-Sensor Aided Targeting - Airborne
MSC	major subordinate command
MSCM	Multi-Spectral Countermeasures

MTTR	mean time to repair
MULE	Modular Unmanned Logistics Express
MWO	Modification Work Order

N

NAS	National Air Space
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVAID	Navigational Aid
NBC	nuclear, biological and chemical
NDI	non-destructive inspection
NDI	non-developmental item
NDT	non-destructive test
NLOS	nonline-of-sight
NOE	nap of the earth
NRDEC	Natick Research, Development and Engineering Center
NRTC	National Rotorcraft Technology Center
NTR	National Transport Rotorcraft (obsolete, see JTR)
NV	night vision

O

O&S	Operating and Support
OBIDS	On-Board Integrated Diagnostics System
OCM	on-condition maintenance
OCR	Operational Capability Requirement
OCSW	Objective Crew Served Weapon
ODCSOPS	Office of the Deputy Chief of Staff - Operations and Plans
OMC	organic matrix composite
OOTW	Operations Other Than War
OPEVAL	operational evaluation
ORD	Operational Requirement Document
OT	operational test
OT&E	Operational Test and Evaluation

P

P3I	pre-planned product improvement
PAR	Precision Approach Radar
PEO	Program Executive Office(r)
PEO-AV	Program Executive Office(r), Aviation
PEO-C3S	Program Executive Office Command, Control, and Communications Systems
PM	powdered metal; powder metallurgy
PM	Program/Project/Product Manager
PM-PWL	Project Manager for Petroleum, Water and Lubricants
POL	petroleum, oil and lubricants
POM	Program Objective Memorandum

R

R&D	Research and Development
R/C	rotorcraft

R/W	rotary-wing
RAM	reliability, availability and maintainability
RASCAL	Rotorcraft-Aircrew Systems Concepts Airborne Laboratory
RCS	radar cross-section
RD&J	Radar Deception and Jamming
RDA	Research, Development and Acquisition
RDAP	Research, Development and Acquisition Plan
RDEC	Research, Development and Engineering Center
RDT&E	Research, Development, Test and Evaluation
recon	reconnaissance
RFI	Radio Frequency Interferometer
RFP	Request For Proposals
RPA	Rotorcraft Pilot's Associate
RPI	Renssellear Polytechnic Institute
RTM	resin transfer molding
RWV	Rotary Wing Vehicle

S

S&T	Science and Technology
S/SU/AC	Systems, Systems Upgrade, and Advanced Concepts
SAL	semi-active laser
SAM	surface-to-air missile
SARAP	Survivable And Reparable Aircraft Program
SBIR	Small Business Innovative Research
SCAS	Stability Control Augmentation System
SECM	Shop Equipment - Contact Maintenance
SFC	specific fuel consumption
SIIRCM	Suite of Integrated Infrared Countermeasures
SIMS	Smart Integrated Microsensor
SINCGARS	Single Channel Ground and Airborne Radio System
SIP	System Improvement Program
SIRFC	Suite of Integrated Radio Frequency Countermeasures
SKO	Sets, Kits and Outfits
SLEP	Service Life Extension Program
SMART	Smart Materials Actuation Rotor Technology
SOA	Special Operations Aviation
SOAR	Special Operations Aviation Regiment
SOUTCOM	U.S. Southern Command
SPO	Systems Project Office (Air Force equivalent of PM)
SPORT	Soldier Portable On-system Repair Tool
SSCOM	U.S. Army Soldier Support Command
STAR	Science and Technology Analysis Report
STAR	System Testbed for Avionics Research
STO	Science and Technology Objective
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command

T

T/P	thermo-plastics
TACAWS	The Army Combined Arms Weapon System

TACOM	Tank-automotive and Armaments Command
TADS	Target Acquisition Designation System
TAIS	Tactical Airspace Integration System
TAP	Technology Area Plan
TARDEC	Tank and Automotive Research, Development and Engineering Center
TD	Technology Demonstration
TECHEVAL	technical evaluation
TEDS	Turbine Engine Diagnostic System
TESS	TADS Engagement Simulation System
TF XXI	Task Force XXI
TF/TA	terrain-following/terrain-avoidance
TIM	Technical Interchange Meeting
TM	technical manual
TOC	Tactical Operations Center
TPA	Technology Program Annex
TPAV	Technology Panel for Air Vehicles
TRADOC	U.S. Army Training and Doctrine Command
TTCP	The Technical Cooperation Program
TTCS	Tactical Terminal Control System

U

U.S.	United States
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UMARK	Unit Maintenance Aerial Recovery Kit
USAATCOM	United States Army Aviation and Troop Command
USAF	United States Air Force
USN	United States Navy

V

V&V	validation and verification
VISEO	Visual and Electro-Optical
VRT	variable residence time
VTOL	Vertical Take-Off and Landing

APPENDIX B: BATTLE LABS AND OPERATIONAL CAPABILITY REQUIREMENTS (OCRS)

The Battle Labs were created in response to the factors and implications of a changing world, strategy, budgetary reality, and a need for a new way of doing business. Battle Labs have demonstrated their value by providing a focus for early investigations and demonstrations of the impacts of new concepts and technologies on warfighting capabilities. In order to assess and prioritize efforts, Operational Capability Requirements (OCR) have been identified by the Battle Labs and the TRADOC community, in coordination with the developer community, as a means to state required and desired capabilities to fulfill that Battle Labs' vision of future warfighting as it relates to the battlefield dynamic of that Battle Lab. The OCRs are statements of capabilities required for the Army to fulfill the vision articulated in the Army Modernization Objectives (TRADOC Pamphlet 525-5 and the Battle Lab concepts). A set of OCRs (TRADOC Pamplet 525-66) is written for each Battle Lab and its assigned battlefield dynamic. These OCRs break out required capabilities into discrete subsets, the aggregate of which when fully realized enables the Army to fulfill the National Military Strategy of decisive dominance of land warfare with minimal casualties. These OCRs are derived from historical lessons learned from operational experience, training exercises, and opportunities provided by technology exploitation. The OCRs are used in Battle Lab S&T reviews as a measure for assessing the warfighting merits of individual S&T and developmental programs, and prioritizing the total Army S&T program. Perceived shortfalls generate a dialogue between the materiel developer and the combat developers and Battle Labs to correct, terminate, or exploit these programs to the advantage of the Army and optimize the limited resources available to pursue these programs.

Battle Command (BC)

Battle command is the ability to envision the desired end state (strategic, operational and tactical military objectives), translate the vision into an intent, formulate concept and courses of action, and provide the force of will to concentrate overwhelming combat power at the right time and place to win decisively with minimal casualties. Decisions must be at the correct time and place to ensure success by leaders who provide a command climate that breeds success, inspires, and moral and physical courage in the face of adversity, and contributes a steady and unshakeable vision that focuses effort and resources toward current and projected requirements. Battle command incorporates two vital components -- the ability to decide and the ability to lead. Control includes the assignment of coordination lines, subdivision of area of operations between friendly forces, and the report structure which flows vital information from commanders to commanders, usually through their respective staffs. Controls aid synchronization and posture the force for current and subsequent operations. Command and control measures used with multinational forces must be tailored to accomodate a myriad of political and military situations. As operations become more complicated, battle commanders must make faster, more complex decisions. To make the best decisions, the commander requires clear and timely information, decision support aids, and better means of communicating intent and mission. The Battle Command Battle Lab OCRs reflect capabilities required by future commanders to exercise battle command throughout the force projection cycle in war and OOTW. The BC Battle Lab is located at Fort Leavenworth, KS, Fort Gordon, GA, and Fort Huachuca, AZ.

Combat Service Support (CSS)

Combat Service Support required for the accomplishment of the Army's post-Cold War missions need to effectively transition the Army to a CONUS-based force projection stance. A Total Distribution System is required to effectively integrate material management and distribution management. Soldier sustainment needed incorporates logistics capabilities to support the individual soldier in forward areas. The focus will be on medical support, field services, and personnel servics. System sustainment improvements are needed to better sustain Army, joint, and coalition weapon systems without the luxury of a well developed mature theater. This includes the capability of tactical CSS units to keep pace with maneuver units and provide CSS during movement. Requirements exist for forward area container handling systems, improved RAM and durability, simplified and more accurate diagnostics and repair procedures, and a prognostics capability that will better predict, provision for, and automatically feed system sustainment software being developed. Improvements are needed in fuels, lubricants, and associated products that will enhance the performance of mechanical systems. Also need improvements in petroleum quality analysis, fuel distribution, and rapid refuel capability. Interoperability and standardization with joint and likely coalition partners is essential to reduce transportation and distribution workload. The CSS Battle Lab is located at Fort Lee, VA.

Depth and Simultaneous Attack (D&SA)

Deep and Simultaneous Attack is the concurrent application of joint and combined combat power against an enemy throughout the depth of the theater of operations. The objective of simultaneous attack in depth is to accelerate the enemy's disorganization, disintegration, and destruction. Overwhelming firepower is applied simultaneously throughout the battlefield, holding the enemy's critical functions at risk. Enemy essential information nodes will be the target of precision deep strike in order to cripple the ability to maintain integrity of his forces. Fighting deep allows us to control the tempo of operations, providing us the opportunity to seize and retain the initiative. Through control of the battle tempo, a condition is created where the enemy as no place to hide and no time to rest. The feasibility of D&SA depends on three conditions. First is the ability to see the entire battlefield. This includes access to national and theater reconnaissance, surveillance, and targeting assets to locate and classify targets. The second is having the advantage in relative combat power. The commander must have a range of complementary attack systems to provide operational fires throughout the battlefield against a full array of enemy targets. The third condition is the capability to synchronize these joint and combined systems and operations. In order to create a single, extended battlefield, targeting information from all available sources must be linked to a common decision making process, which executes fires using all accessible delivery means. The joint nature of deep operations implies that the standards and protocols incorporated in future technology developments is a key issue. All of these capabilities must be versatile, deployable, lethal, and expandable to support the power projection paradigm of today's Army. The D&SA Battle Lab is located at Fort Sill, OK.

Dismounted Battle Space (DBS)

Battle space is that volume of the battlefield determined by the maximum capabilities of a unit to acquire and engage the enemy with both organic and supporting systems. The size, shape and density of a given unit's battle space, as it applies to both mounted and dismounted forces, is variable depending upon METT-T and level of command. The concept of battle space goes beyond three dimensions to include time and the mental construct ability to visualize enemy and friendly activity (i.e., get inside his head and predict actions and reactions). Forces operating in dismounted battle space include light, special operations, and dismounted elements of armored forces. These forces are

organized into combined arms task forces at brigade level and below, with combat, combat support (CS) and combat service support (CSS) capabilities tailored for the specific combat or OOTW mission. Overmatch combat power by forces in dismounted battle space is essential to decisively defeat enemy forces during combat and to rapidly accomplish the mission. Overmatch is the primary consideration for successful dismounted battle space operations and desired in all aspects of combat power: maneuver, firepower, protection, and leadership. The DBS Battle Lab is located at Fort Benning, GA.

Mounted Battle Space (MBS)

Battle space is a construct, a way to think about fighting, visualizing every level of the entire battlefield and all phases of the campaign and operation. Proper use of the construct prevents our combat, combat support, and CSS units from becoming surprised or paralyzed by unexpected enemy actions. From the introduction of our forces, we dominate the battlefield by dominating maneuver. The construct demands that the leader understand the time and space limits, not necessarily constrained by terrain, where his force can detect, acquire, and engage the enemy. Application of mounted battle space involves the leader and battle command in a complex equation of terrain, the enemy, mobility and agility, force protection, and weapons. Battle Command is the glue, providing redundant C3 and the ability of leader to fight with all systems and units horizontally integrated. Mobility and agility are the tool of innovation used by commanders to provide momentum to control the opponent. Force protection, inboth active and passive modes such as decoys, electronic countermeasures, stealth technology, and vehicle-integrated defense systems, will raise vehicle survivabilty to new levels. Weapons remain the core of our ability to control the battlefield. By increasing ranges at which we detect, acquire, identify, engage, and destroy or neutralize our adversary in the close fight, we will continue to own several distinct advantages over the enemy so we can increasingly mass effects and not forces. This allows us to increase our lethality, seize and maintain the initiative, reduce the vulnerability of our forces, and enhances our ability to maneuver by improving our base of fire and enhances the flexibility of our force. The Mounted Battle Space Battle Lab is located at Fort Knox, KY.

Early Entry Lethality and Survivability (EELS)

Early entry forces, the Army's first to fight forces, must be lethal, survivable, and deployable to gain rapid entry into the operational are, secure the lodgment, and have an immediate effect prior to the arrival of follow-on forces which conduct decisive operations. Logistical support for early entry is a major concern as they will likely be bare based and the operations area may lack required infrastructure such as ports, rails, water, and power grids. The EELS Battle Lab is located at Fort Monroe, VA.

Crosswalk to Aviation S&T Programs

The following pages (Tables B-1 thru B-4) provide a macro-level linkage between the aviation S&T programs and the battlefield dynamics. The crosswalk shows which battle labsbattlefield dynamics each program relates and the degree of contribution. A more detailed identification down to the specific OCRs is not provided as the identifying OCR reference numbers will not remain static over the life of this Plan.

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: **PEO-Aviation and ATCOM - AVRDEC**

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability: BC	CSS	D&SA	DBS	MTD	EELS
6.2	62211	A47A	47A05	DA2025	**Advanced Concepts.** (Bird Dog, JTR, MRMAAV, FAAV, Airborne MULE, FUR, etc.)		●	○		○	
6.3	63003	D313	31304	NTR3000	**Joint Transport Rotorcraft (JTR).** Increased survivability, payload, and range. Increased mobility.		●	●	●	●	●
6.3	63003	D436	43602	ATD3102	**Bird Dog.** Increased lethality and survivability. Improved situational awareness and C3I. Real-time intelligence, reconnaissance, targeting, and BDA.	●	○	●	●	●	●
6.3	63003	D313	TBD	TBD	**Multirole Mission Adaptable Air Vehicle (MRMAAV)**		○	○	○	○	○
6.3	63003	D313	TBD	TBD	**Airborne MULE.**		●				
6.2 6.3	62211 63003	A47A D313	47A09 TBD	NRTC200 NRTC300	**National Rotorcraft Technology Center (NRTC).** Increased survivability and lethality, reduce O&S costs.		●	○	○	○	○
6.4 / 6.5 6.4 / 6.5	64223 64223	D327 DC72	01 01		**RAH-66 Comanche.** Increased lethality and survivability. **T800 Engine.** Increased maintainability and durability. Reduced logistical burden. Increased range and payload.	● 	 ○	● ○	● 	● ●	● ○
6.5 6.5	64220 64220	D518 D538	01 01		**OH-58D Kiowa Warrior.** Increased lethality and survivability. **OH-58D CSMET.** Increased lethality and survivability.	●	○	●	○	●	●
6.5 6.5	64816 64816	DC27 DC31	01 01		**AH-64D Longbow Apache.** Increased lethality and	○		●	●	●	●
6.7	23744	D423	01		**Enhanced AH-64.** Increased lethality.	○		●	●	●	●
6.7 6.7	23744 23744	D179 D430	01 01		**CH-47D (IMP) / Improved Cargo Helicopter (ICH).** Increased survivability and payload.		●	●	●	●	●
6.7	23744	DXXX			**Improved UH-60.** Increaesd survivability and payload.		●		●	●	●
6.7					**MH-60K.** Increased lethality				●		●
6.7					**MH-47E.** Increased lethality				●		●

Table B-1. Crosswalk of Battlefield Dynamics to Aviation S/SU/ACs.

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: ATCOM - AVRDEC

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability					
						BC	CSS	D&SA	DBS	MTD	EELS
6.1	61102	AH45	H4501	AER1001	**Research in Aerodynamics** Increased survivability. Increase capability to engage stationary and moving targets.		○	○	○	●	○
6.1	61102	AH45	H4502	AVR1004	**Avionics Basic Research.** Reduce pilot workload.	○		○		○	
6.2	62211	A47A	47A01	AE2051	**Aerodynamics Technology** Increased survivability. **Rotorcraft Pilot's Associate (RPA) ATD.** Increase lethality and survivability.	○	●	●	●	●	●
6.2	62211	A47A	47A02	AE2035	**Control / Maneuverability / Handling Qualities** Increase information awareness survivability. Improve handling qualities at night & poor weather; reduce complexity of flight controls; reduce spare parts & maintenance actions; improve weapons pointing accuracy.		●	○	●	●	●
6.2	62211	A47A	47A04	AT2050	**Reliability / Maintenance**		●				
6.2	62211	A47A	47A02	AF2061	Flight Simulation. Optimize handling qualities & performance in operations.					●	
6.2	62211	A47A	47A05	AS2017	**Aircraft Systems Synthesis** Concepts for system improvements & future concepts.		●				
6.2	62211	A47A	47A05	DA2025	**Advanced Concepts** Concept exploration & benefits.		●	○		○	
6.2	62211	A47A	47A08	AF2033	**Man-Machine Integration** Increased lethality. Increased survivability. Improve situational awareness, enhance dissemination of C4I Air-to-Air combat capability.		○	○	○	●	○
6.2	62211	A47A	47A08	AF2075	**Aircrew Aircraft Integration** Increased lethality. Increased survivability. Increase capability to engage stationary and moving targets. Increase information awareness. Reduce pilot workload.	○		○	○	●	○
6.2 6.3	62211 63003	A47A D313	47A09 TBD	NRTC200 NRTC300	**National Rotorcraft** Technology Center (NRTC). Increased survivability and lethality, reduce O&S costs.		●	○	○	○	○

Table B-2. Crosswalk of Battlefield Dynamics to Aviation S&T.

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: ATCOM - AVRDEC

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability: BC	CSS	D&SA	DBS	MTD	EELS
6.2	62211	A47A	47A06 47A07	AT2034 AT2044	**High Temperature Components** Increased survivability. Reduce fuel consumption, increase power-weight ratio.		○	●	○	●	○
6.2	62211	A47A	47A06 47A07	AT2055 AT2045	**Compressor Drive** Increased survivability, lift, and speed. Extend range, reduce fuel.		○	●	○	●	○
6.2	62211	A47A	47A03	AT2036	**Design Critical / Analysis** Increased lethality and Increase information awareness. Increased range and payload. Reduce support equipment, infrastructure and O&S costs. Improve operational availability.		●	●	●	●	●
6.2	62211	A47A	47A04	AT2063	**Vulnerability and Safety** Increased lethality and survivability. Increase range and payload. Reduce vulnerability to ballistics and RF/DEW and Improve crash safety. NBC contamination reduction.			●	○	○	○
6.2	62211	A47A	47A04	AT2027	**Detection and Countermeasures** Increased survivability. Acoustic, RF, and IR/EO signature reduction.			●	○	●	●
6.2	62211	A47A	47A05	AT2028	**Weapons Integration Concepts.** Increased lethality. Increase capability to engage stationary and moving targets. Air-to-Air combat capability. Reduce pilot workload.			○	○	●	○
6.3	63003	D313	31305	ATD3191	**Autonomous Scout Rotorcraft Testbed (ASRT).** Increased lethality and survivability. Real-time situational awareness, intelligence, targeting, BDA.	●	○	●	●	●	●
6.3	63003	D313	31302	ATD3190	**Manufacturing And Structures Technology for Efficient Increased lethality.** Increased Survivability. Increase range/payload. Reduce LLC / O&S.		●	●	●	●	●
6.3	63003	D313	31303	PRP3157	**Advanced Rotorcraft Transmission (ART) II TD.** Increased survivability, lift, speed, and range. Logistical mobility, reduced fuel consumption, and increased power-weight ratio.		●	●	○	●	○

Table B-3. Crosswalk of Battlefield Dynamics to Aviation S&T (continued).

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: **ATCOM - AVRDEC**

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability					
						BC	CSS	D&SA	DBS	MTD	EELS
6.3	63003	D313	31301	AFD3158	**Helicopter Agility and Control Technology (HACT) TD. Rotorcraft Pilot's Associate (RPA) ATD.** Increase lethality and survivability. complexity, spare parts and maintenance. Increase OPTEMPO. Increase information awareness.		●	○	●	●	●
6.3	63003	D313	31304	NTR3000	**Joint Transport Rotorcraft (JTR) ATD.** Increased survivability, payload, and range. Increased mobility.		●	●	●	●	●
6.3	63003	D313	TBD	TBD	**Multirole Mission Adaptable Air Vehicle (MRMAAV) TD**		○	○	○	○	○
6.3	63003	D313	TBD	TBD	**Airborne MULE.** Increase survivability, payload, and range.		●				
6.3	63003	D313	31301	TBD	**3rd Generation Advanced Rotor Demo (3rd GARD).** Increased survivability, payload, range and speed.		○	○	○	○	○
6.3	63003	D313	TBD	ATD3195	**Full Spectrum Threat Protection (FSTP)** Increased survivability by developing active and passive countermeasures.			○	○	○	
6.3	63003	D313	TBD	TBD	**Survivable Affordable Air-to-Air combat capability. (SARAP).** Increased survivabiltiy/maintainability.		○	○	○	○	○
6.3	63003	D313	TBD	TBD	**Aircraft System Self-Healing (ASSH).** Increased survivabiltiy/maintainability.		●		○	○	○
6.3	63003	D313	TBD	ATD3196	**On-Board Integrated Diagnostics System (OBIDS).**						
6.3	63003	D435	43502	ATD3108	**The Army Counter Air Weapons System (TACAWS) Increased lethality. (ATA/ATG) TD.** Increased lethality.			●	○	●	○
6.3	63003	D435	TBD	TBD	**Precision Guided Mortar Munitions.** Increased lethality			○	○		
6.3	63003	D435	43502	ATD3108	**Advanced Weapons Integration Program (AWIP).** Increased lethality. Acquire and engage targets at increased range and in clutter. Real time ATR day/night/all weather. Tailorable kill level, reduced collateral damage, reduced cost per kill.			●	○	●	●

Table B-4. Crosswalk of Battlefield Dynamics to Aviation S&T (continued).

R&D Program / Battle Lab Battlefield Dynamics Crosswalk

Organization: **ATCOM - AVRDEC**

RDT&E Funding	Program Element	Project	Task	Work Package	Title/Description of Project	Battlefield Dynamics Applicability: BC	CSS	D&SA	DBS	MTD	EELS
6.3	63003	D436 D435 D436 D436 D436 DB97 DB97	43601 43501 43601 43601 43601 B9702 B9702	ATD3101C ATD3096C AFD3161 AFD3103 ATD3068 AV3918 AV3920C	**Rotorcraft Pilot's Associate (RPA) ATD.** Increase lethality and survivability. Increase capability to engage stationary and moving targets. Increase information awareness. Reduce pilot workload. Enhanced communications, mission planning, & battlefield effectiveness.	●	○	○	○	●	○
6.3	63003	D436	43602	ATD3102	**Bird Dog ATD.** Increased lethality and survivability. Improved situational awareness and C3I. Real-time intelligence, reconnaissance, targeting, and BDA.	●	○	●	●	●	●
6.3	63003	D436	43604	AFD3105	**Advance Integrated Pilotage System (AIPSYS) for NOE Flight Operations.** Increase survivability. Reduce pilot workload.	○	○	○	○	○	○
6.3	63003	D447	44701 44702	ATD3168 ATD3169	**Joint Turbine Advanced Gas Generator (JTAGG).** Increased survivability, payload, and range.		○		○	○	○
6.3	63003	D447	44701 44702 44701	ATD3168 ATD3169 ATD3065	**Integrated High Performance & Turbine Engine (IHPTET)** Increased survivability. Extend range, reduce fuel consumption, increase power-weight ratio.		○	●	○	●	○
6.3	63003	D447	TBD	TBD	**Alternative Propulsion Sources (APS)** Increased survivability, payload, and range.		○	○	○	●	○
6.3	63003	DA38	A3801	CONG1	**Starstreak** Air-to-Air combat capability.			○		●	○
6.3	63003	DB97	B9701	AV3821B	**CAV2 / Aviation Tactical Operations Center (AVTOC).** Increased lethality, survivabilitly, and communication range.	●	○	○	○	○	○
6.3	63003	DB97	TBD	TBD	**4th Generation Crew Station** Increased survivability. Improved situational awareness.	○		○	○	○	○
6.4	63801	DB32			**Logistics Rearmament-Aviation (Log Rearm-AVN)** Increased lethality. Improved readiness. Improved survivability (FARP).	○	●	○	○	○	○

Table B-5. Crosswalk of Battlefield Dynamics to Aviation S&T (conclusion).